INRS

Université d'avant-garde

Centre - Eau Terre Environnement

Annual Report 2007-2008

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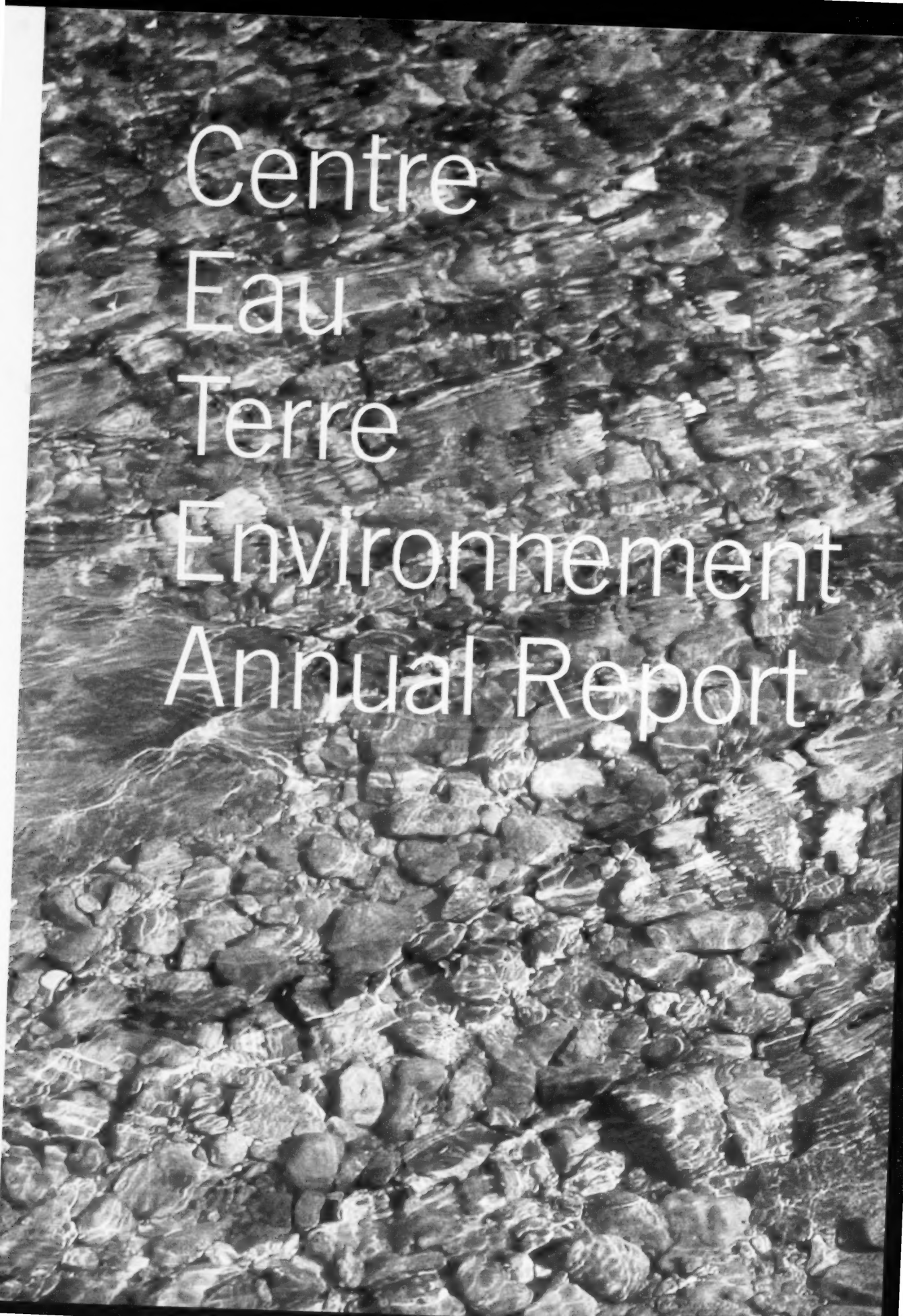
Centre
Eau
Terre
Environnement
Annual Report

The Centre is engaged in the sustainable development of Quebec in the fields of water sciences, geo-resources, and the environment

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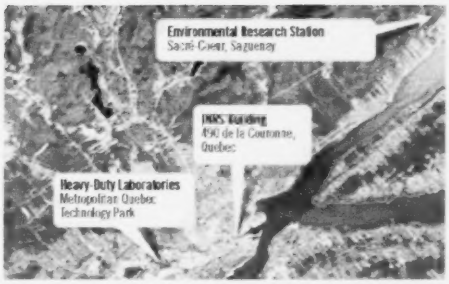
Centre Eau Terre Environnement and the INRS network

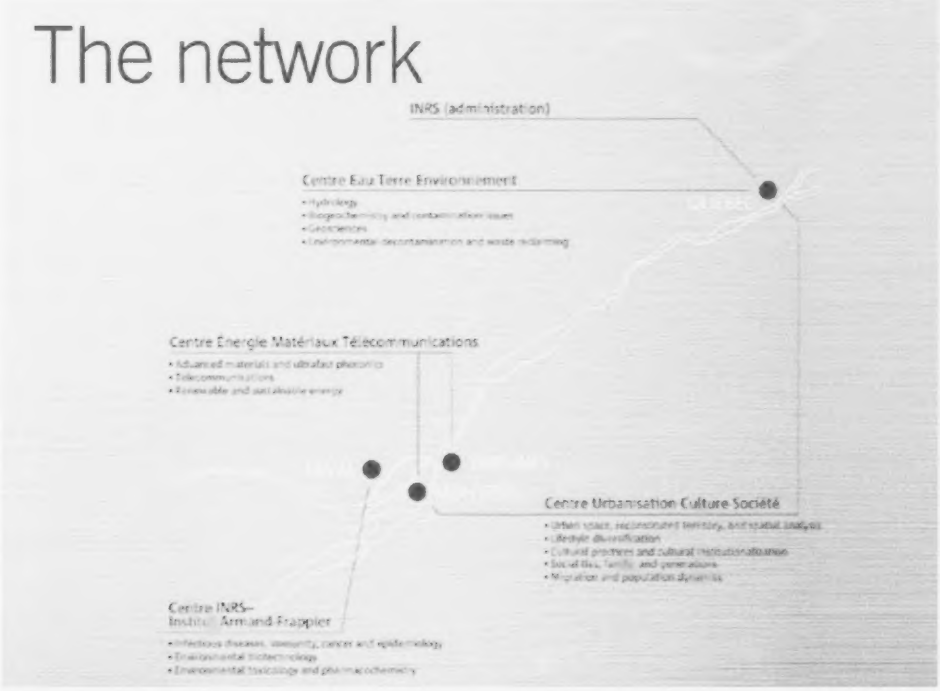
The mission of the *Institut national de la recherche scientifique* (INRS: Quebec's national institute of scientific research) is to conduct pure and applied research for the social, economic, and cultural benefit of Quebec. This university research institution seeks to train highly qualified professionals at the graduate level (Master's, PhD and postdoctoral) in its areas of scientific expertise.

The INRS is composed of four branches: a research centre on energy, materials, and telecommunications (*Centre Énergie Matériaux Télécommunications*), a research centre on health (*INRS - Institut Armand-Frappier*), a research centre on urbanization, culture, and society (*Centre Urbanisation Culture Société*), and a research centre on water, earth, and the environment (*Centre Eau Terre Environnement*). The INRS offers to its students and researcher-professors an innovative research environment focused on society's needs.

The Centre Eau Terre Environnement is actively engaged in the sustainable development of Quebec, particularly in the fields of water sciences, georesources, and the environment. Research at the Centre is multidisciplinary and has strong laboratory and field components, enabling the study of complex problems such as climate warming and environmental risks related to pollution. The Centre makes an important contribution to the integrated management of resources and regional planning and plays a part in the restoration of urban and natural environments with the help of new environmental technologies. The Centre is based in downtown Quebec City within the urban campus of the *Université du Québec*, its heavy-duty laboratories are located at the Metropolitan Quebec Technology Park, and it has an environmental research station at Sacré-Coeur, not far from the mouth of the Saguenay River.



The network



A global vision for sustainable environmental development

The Centre Eau Terre Environnement contributes to the INRS mission of research, education, and the transfer of scientific and technical knowledge through its work on the integrated management, conservation, and sustainable development of water and earth resources. The Centre is addressing major environmental issues of current concern to the world's governments, such as the need for reasonable and safe use of water and earth resources, the necessity to prevent environmental risks, and the need to respect natural ecosystems. The Centre is dedicated to finding practical solutions, focusing in particular on natural processes of remediation and new environmental technologies. The Centre's vision is based on a strong environmental commitment and a rigorous and innovative scientific approach. Its research is at the forefront of scientific and technological advances facilitating the establishment of good practices in protecting and developing natural resources.

Jean-Daniel Bourgault

Monique Bernier

Message from the Director

I am pleased to present the 19th annual report of the *Centre Eau Terre Environnement* of the *Institut national de la recherche scientifique* for the year 2007-2008. The mission of the Centre is to conduct pure and applied research and train highly qualified professionals in the fields of water sciences, georesources, and the environment. Our objective is to contribute to the sustainable development of Quebec's natural resources. The Centre's mission also includes sharing knowledge and technology transfer. This annual report outlines the outstanding events and activities of the Centre Eau Terre Environnement during 2007-2008.

The scientific program of the Centre is divided into four main research fields: hydrology, waste decontamination and reuse, aquatic and terrestrial biogeochemistry, and geological sciences. Within each field, the main research projects carried out in 2007-2008 are briefly described in the report.

In 2007-2008, the International Polar Year (IPY) provided a good opportunity for Centre Eau Terre Environnement researchers to work actively with the national and international scientific communities. INRS researchers participated in seven major IPY projects. Another international research initiative, the Potrok Aike Maar Lake Sediment Archives Drilling Project (PASADO), officially began in 2008. Pierre Francus leads the Canadian contribution to this important study.

This year's report contains a map highlighting the Centre Eau Terre Environnement's presence throughout the world, including active research sites and the countries of origin of researchers, students, and collaborators. More than 25 guest professors and researchers from around the world came to the Centre this year.

Some outstanding events of the year

In June 2007, the arrival of six new professor-researchers greatly enhanced the Centre's research expertise. In hydrology, Karem Chokmani (remote sensing) and Sophie Duchesne (urban hydrology), in waste decontamination, Satinder Kaur Brar (biological detoxification) and Patrick Drogui (electrochemistry), and in geosciences, Erwan Gloagen (hydrogeophysics) and Pierre-Simon Ross (volcanology and applied geology).

In October 2007, we completed construction of a new building to house the heavy-duty laboratories of the Centre. Located in the Metropolitan Quebec

Technology Park, this research facility contains high-tech equipment that will enable the scaling of technologies developed at the INRS.

In November 2007, a celebration was organized for Dr. Jean-Pierre Villeneuve to mark the end of his term as the Centre's director. It was an opportunity both to highlight Dr. Villeneuve's achievements for the Centre and to recognize the strength of the research teams that he helped to build over the years.

In December 2007, the Centre acquired a research station at Sacré-Cœur, not far from Tadoussac at the mouth of the Saguenay River. This research station will facilitate research on boreal rivers and also serve as an educational facility.

In April 2008, the Centre consolidated its collaboration with Morocco by contributing to the creation of the *Institut supérieur des hautes études en développement durable* (ISHEDD). This institute will bring together North African and European partners within training programs in water sciences.

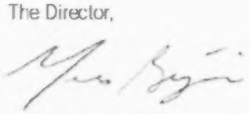
In May 2008, the INRS hosted the 76th ACFAS Congress. The conference theme, "Knowledge meets 400 years of history", was linked to the 400th anniversary of Quebec City. This annual meeting is the most important scientific event in Quebec. It was a great success this year, with more than 4400 participants. Professor Villeneuve was the president of the congress.

Other notable events of 2008 included the very successful 9th Earth and Environmental Sciences Day, hosted in March at the Centre Eau Terre Environnement. The 20th anniversary of the *Journal of Water Science*, which is co-edited by the Centre, was also celebrated in 2008.

This report thus highlights the main achievements of the Centre Eau Terre Environnement during 2007-2008. Credit for those achievements belongs to the entire hard working Centre Eau Terre Environnement community, including some 40 professor-researchers, more than 200 graduate students and postdoctoral fellows, and the staff of the Centre, all of whom contributed their share to the success of our establishment.

I would like to sincerely thank everyone who contributed to this report through his or her activities.

The Director,



Yves Bégin

Multidisciplinary research

The Centre Eau Terre Environnement is a leader in environmental research. The Centre's multidisciplinary research on environmental technologies, cutting edge methods of detecting environmental changes in ecosystems, innovative approaches to integrated management of resources, and numerical modeling of underlying natural and environmental processes bring together important scientific knowledge on the environment. Its research teams study water and earth resources with the aim of contributing to an informed and sustainable use of these resources.

The scientific program of the Centre Eau Terre Environnement is divided into four main research fields: hydrology, waste decontamination and reuse, aquatic and terrestrial biogeochemistry, and geological sciences. These fields share many common strategic axes, such as risks related to extreme natural events or contamination of human origin; the impact of climate change on resources and their use, and the adaptations necessary to respond to these changes; the management of hydrological and mineral resources and resulting regional planning; and restoration and decontamination technologies for urban and natural environments.

Hydrology research and ongoing projects

Canada has approximately 6% and Quebec nearly 2% of the world's fresh water resources. Management, decontamination, and protection of this vital resource are thus priority research subjects at the INRS. Work is carried out in hydrology, hydrogeology, biogeochemistry, water quality, and environmental technologies. The Centre Eau Terre Environnement hosts the most important group of university experts in water research in Canada.

Research in hydrology focuses specifically on predictive statistics (flood and ice jam prediction, impact of climate change on occurrence of extreme hydrological events, tools to assist in the design of hydroelectric structures, etc.), watershed hydrology (integrated management tools for sustainable water use and quality), urban hydrology (infrastructure, impact of climate change on water supply, contamination by runoff, etc.), and environmental hydraulics (flood risk, impact of climate change on the forest environment, erosion, etc.). The Centre's aquatic research also has a northern physical oceanography component. A research team specializes in the study of the circulation and evolution of the sea surface layer and tides in order to better understand the physical processes involved and their impact on marine life and habitats.

• Statistical hydrology

Several of **Taha B.M.J. Ouarda**'s research projects concern the impact of and adaptation to climate change. A project of the Ouranos Consortium (Consortium on Regional Climatology and Adaptation to Climate Changes) in collaboration with Quebec's National Institute of Public Health explored the relationships between climate and mortality in order to find the best statistical explanatory model.

Quebec's Ministry of Sustainable Development, Environment and Parks is interested in the impact of climate change on groundwater. Taha Ouarda thus conducted a preliminary study on the development of a groundwater level monitoring network.

Another project of this researcher, financed by Environment Canada, seeks to determine the relationships between suitable climatic variables, their evolution, and hydrological extremes (floods, low water levels). The resulting knowledge and tools will be useful for developing adaptive strategies for water resources in Canada.

Within the Hydrology and Climate Working Group of the International Joint Commission on the management of the Great Lakes, Taha Ouarda is working to identify changes that have occurred in the characteristics of the lakes and their watersheds (lake levels, precipitation, flows, evaporation, etc.) to determine the links with explanatory variables and to study the relationships between Great Lakes levels and various indices of low frequency climatic oscillations.

This researcher also continues to improve the software REGIONS (Regionalization of Extreme Hydrological Events) by integrating the latest methodologies developed by the research team of the Chair in

Yves Bégin

Statistical Hydrology. This project is financed by Hydro-Québec, which uses this software.

Lastly, Taha Ouarda has undertaken a study for the Canadian Coast Guard re-evaluating the under-keel clearance (UKC) standard for ships using the St. Lawrence shipping channel in order to propose a new statistical methodology for modeling UKC that complies with the rules and enables rational modeling of risks. UKC integrates a variety of components, of which the most important is the squat, the additional sinkage caused by a ship's movement.

In collaboration with the research institute of Hydro-Québec, **Anne-Catherine Favre** is developing a methodology for multivariate frequency analysis to be used to determine the design flow of a hydraulic structure. The ultimate goal is to apply this methodology to the annual maximum levels of the Romaine River.

Another research project of Anne-Catherine Favre seeks to integrate ensemble weather forecasts from Environment Canada with short-term hydrological forecasts in order to account for the uncertainty of weather data. Short-term hydrological forecasts are necessary to manage surface waters effectively, especially in crisis situations such as floods.

As part of an international partnership (collaboration with the ENSEMBLES project of the European Community: www.ensembles-eu.org), **Andre Saint-Hilaire** and **Taha B.M.J. Ouarda** work on developing scenarios of climate change at high spatial resolution. Their work consists of evaluating quantitatively the uncertainty associated with scenarios generated within a probabilistic framework in order to offer extra information to the users on scenario probabilities.

André Saint-Hilaire is interested in river habitats. His research increases our knowledge on variables such as thermal regime and concentration of solids in suspension by developing stochastic estimation models. He has worked on multivariate geostatistical modeling for water temperature.

This researcher also seeks to minimize the environmental impacts of peatland harvesting by developing approaches to reduce the sedimentary load produced by these activities.

For more information

Benyahya, L., D. Caissie, A. St-Hilaire, T. B. M. J. Ouarda, and B. Bobée. 2007. A review of statistical water temperature models. *Can. Water Resour. J. / Rev. Can. Ressour. Hydr.* 32, no. 3: 179–92.

http://pubs.nrc-cnrc.gc.ca/cwrj/cwrj3203179.html

Tramblay, Y., A. St-Hilaire, and T. B. M. J. Ouarda. 2008. Frequency analysis of maximum annual suspended sediment concentrations in North America. *Hydrol. Sci. J.* 53, no. 1: 236–52.

http://dx.doi.org/10.1623/hysj.53.1.236

Within the GEOIDE Network (Geomatics for Informed Decisions), **Monique Bernier** leads the FRAZIL project (Integrated Expertise Towards the Development of an Ice Jam Related Flood Warning System) with the collaboration of **Taha B.M.J. Ouarda**. The project's goal is to develop a mapping software solution meeting the specific needs of ice-jam–related flood prevention, dam management, and control of winter navigation.

Monique Bernier also seeks to integrate information derived from radar polarimetry (ENVISAT, RADARSAT-2) in decision support systems for the monitoring of snow cover, soil freezing, and flood and ice jam forecasting.

Within the National Agri-Environmental Standards Initiative, **Alain Rousseau** collaborated with Environment Canada in developing an approach for hydrological modeling to be used for determining agri-environmental performance standards for pesticides using the GIBSI (*Gestion Intégrée des Bassins versants à l'aide d'un Système Informatisé*) model developed at the INRS and the SWAT (Soil and Water Assessment Tool) model developed by the USDA. Pesticide standards are defined as the concentration levels that can be reached by using good management and agricultural practices and the technologies available. The GIBSI model has been applied to four Canadian watersheds. The long-term results will contribute to the understanding and prevention or reduction of environmental and human health threats posed by toxic substances.

In the Bras d'Henri (BH) sub-basin, beneficial management practices (BMPs), such as buffer strips, reduced herbicide use, manure management, and crop rotation, have been implemented. This project, carried out in collaboration with Agriculture and Agri-Food Canada seeks to use the GIBSI model to characterize water quality after implementation of BMPs in the BH and to generate prototype software based on GIBSI to examine the economic and environmental compromises of BMPs in the BH and at the watershed scale for the Beaurivage River (Chaudière-Appalaches region). Hydrological modeling is carried out by Alain Rousseau and his team.

Hydrological modeling has also been used by this researcher and his team to evaluate changes in river flows after forest harvesting in relation to the developmental stages of forest cover and harvest effects on chemical substance balance in the Montmorency Forest.

Finally, Hydro-Québec via Ouranos is interested in pursuing the development and adaptation to the boreal context of the hydrological model HYDROTEL in order to better understand and predict the historical and future hydrological behaviour of its northern basins for planning hydroelectric production. This project is carried out by a team of INRS researchers including Alain Rousseau.

For more information

Gumiere, R., and A. N. Rousseau, 2007: GIBSI: An integrated modeling system for watershed management - sample applications and current developments. *Hydrol. Earth Syst. Sci.*, 11, no. 6, 1785-95.

http://www.hydrol-earth-syst-sci.net/11/1785/2007/

Boucher, E., A. N. Rousseau, A. R. Plamondon, D. Levesque, and S. Jutras, 2008: Rainfall peak flow response to clear-cutting 20% of a boreal small watershed in a boreal forest, Montmorency Forest, Quebec. *J. Hydrol.*, 352, no. 1-2, 67-76.

http://dx.doi.org/10.1016/j.jhydrol.2007.12.028

Karem Chokmani is a new researcher-professor at the INRS. His research interests relate to the estimation and monitoring of water resources by using remote sensing and geomatic tools data in hydrology. Quebec's Ministry of Sustainable Development, Environment and Parks has mandated him to explore the feasibility of detecting field flows towards the surface drainage network from manure piles and winter enclosures, using satellite imagery at very high spatial resolution. The ministry's objective is to develop a methodology to evaluate and monitor these manure storage techniques in order to determine if they constitute potential sources of water contamination.

Jean-Pierre Villeneuve continued his work on applied mathematical models and optimal management of water resources with the goal of developing tools and approaches allowing optimal use of the resource while ensuring its protection. His work focuses specifically on flows, transport, and water quality at the watershed scale (natural and urban).

An international project

Country: **Vietnam**

Official language: **Vietnamese**

Partner: Vietnamese Academy of Science and Technology (VAST)

Funding: Canadian International Development Agency (CIDA)

Jean-Pierre Villeneuve leads a project on the integrated management of the **Cầu** River watershed, a successful example of an international scientific collaboration. The Centre Eau Terre Environnement's expertise in integrated watershed management is used advantageously in this Canada-Vietnamese partnership to improve the water quality of rivers and lakes in Vietnam. The watershed of the highly polluted **Cầu** River was selected for development of this new approach. At the end of the project (in 2012), intervention scenarios will be provided to improve water quality while ensuring economic development of the area within a watershed development approach.

Dự án « Quản lý tổng thể lưu vực sông Cầu » do giáo sư Jean-Pierre Villeneuve phụ trách là một ví dụ điển hình của hợp tác quốc tế về khoa học. Dự công tác giữa Canada và Việt Nam hướng tới mục đích tận dụng những kinh nghiệm của Trung tâm Đất, Nước và Môi trường - Viện Nghiên cứu khoa học quốc gia Québec trong lĩnh vực quản lý tổng thể nguồn nước của lưu vực sông nhằm nâng cao chất lượng nước sông hồ Việt Nam. Lưu vực sông Cầu ô nhiễm từ nhiều năm được chọn để áp dụng cách tiếp cận mới về quản lý này. Trong giai đoạn hợp tác (2012), dự án sẽ xây dựng nhiều tình huống tác động có thể xảy ra nhằm nâng cao chất lượng nguồn nước trong quá trình phát triển kinh tế vùng phù hợp với những nguyên tắc của phát triển bền vững.

Translation: Ha Pham Thi Thanh

• Urban hydrology

Like other research areas, urban hydrology is addressing the impact of climate change. **Alain Mailhot** and his team currently have several research projects specifically focused on this issue. At the request of Quebec's National Institute of Public Health, this research team carried out an analysis of predictions for future precipitation and water flows in southern Quebec in order to determine potential risks associated with drinking water supply.

Climate change will likely modify the recurrence and intensity of heavy rainfall events and thus increase the risk of overflow in urban drainage networks and the risk of flooding in urban environments. In collaboration with the Ouranos Consortium, Alain Mailhot and his team developed an approach integrating climate change into the design and planning of urban drainage infrastructure renewal. Various adaptation strategies are also being considered in order to maintain the functionality of drainage infrastructures in the face of climate change. One such project is currently underway in Montreal to study and simulate different adaptation strategies and analyze implementation conditions in a urban context.

Sophie Duchesne is a new researcher-professor at the INRS. Her research interests relate to the development of mathematical models and adaptation of existing algorithms (flow simulations, water quality, infrastructure behaviour), and the use of methods based on these models, to improve management of water resources and infrastructures. Her current work focuses on modeling the ageing of sewage lines to plan repair and replacement work. One of her particular interests concerns the management and modeling of rain water in urban environments.

For more information

Mailhot, A., S. Duchesne, D. Caya and G. Talbot, 2007. Assessment of future change in intensity-duration-frequency (IDF) curves for southern Quebec using the Canadian regional climate model (CRCM). *J. Hydrol.* 347, no. 1-2: 197-210.

http://dx.doi.org/10.1016/j.jhydrol.2007.09.019

• Environmental hydraulics

Normand Bergeron participates in the Geosalar II project of the GEOIDE Network. Geosalar II is conducting integrated modeling of juvenile Atlantic salmon movement and physical habitats in fluvial and estuarine environments. It seeks to understand how temporal and environmental variations influence salmon behaviour and reproduction.

In collaboration with Quebec's Ministry of Natural Resources and Wildlife, Normand Bergeron carried out an evaluation and monitoring of fish for a multi-species fish ladder on the Feu stream at Lachenaie (Montreal region). This researcher also continues his work to improve knowledge about river shapes and processes that affect the winter habitat of salmon.

An environmental consulting firm using the MODELEUR/HYDROSIM simulation software conceived at the INRS has contracted with **Yves Secretan** to use his expertise in 2D hydrodynamic and habitat modeling.

An international project

Country: **Mexico**

Official Language: **Spanish**

Partner: Centre de recherches et d'études avancées de l'Institut Polytechnique National (CINVESTAV)

Funding: International Development Research Centre (IDRC)

Funding for research cooperation between Canada, Latin America and the Caribbean enabled the multidisciplinary expertise of the Centre Eau Terre Environnement and the National Polytechnic Institute of Mexico to be brought together. The objective was to use software developed at the INRS to analyze data on three coastal lagoons of the Yucatán peninsula collected over several years by Mexican researchers. **Yves Secretan** collaborated in the development of numerical models to analyze current dynamics, simulate contaminant transport, and evaluate habitat quality and availability for these lagoons. The results will help in decision making for the sustainable management of these ecosystems, which are unique in term of biodiversity but are currently threatened by human activities. This collaboration will contribute to creating a network between Mexican and Canadian researchers and institutes.

Una subvención para la colaboración científica entre Canadá, América Latina y las Antillas ha permitido la puesta en común de los peritajes multidisciplinarios del Instituto Politécnico Nacional de México y del Centro Eau Terre Environnement. El objetivo era se poner la información sobre las lagunas costeras de la península del Yucatán que fue recogida desde muchos años por los investigadores mexicanos a la información obtenida por modelización en el INRS. Yves Secretan ha colaborado al desarrollo de modelos numéricos que permiten de analizar la dinámica de las corrientes de las lagunas, simular el transporte de los contaminantes y evaluar la calidad y la disponibilidad de los hábitats. Los resultados podrán ayudar a mejorar la gestión sostenible de los ecosistemas de las lagunas, únicos en términos de biodiversidad y amenazados por la actividad humana. Esta colaboración favorecerá la creación de los lazos de cooperación entre investigadores mexicanos y canadienses.

Collaborators: Cesia Rosario Mendoza et Martin Durand

• Oceanography

Yves Gratton is part of a research team interested in modeling ecosystem responses to climate change in the Canadian Arctic archipelago. He specifically studies tidal and wind effects on the mixed layer, as well as the transport of fresh water, heat, ice, and nutrients in this archipelago. Yves Gratton was one of the project leaders in phase I of the research of the ArcticNet Network, which was completed in March 2008. His project studied the physical and biological coupling between the ocean, sea ice, and the atmosphere in the High Arctic. Yves Gratton is also conducting other research on mid-scale physical processes and their impacts on the biological production of the Canadian Arctic.

For more information

Forest, A., M. Sampei, R. Makabe, H. Sasaki, D. G. Barber, Y. Gratton, P. Wassmann, and I. Fortier (2008), The annual cycle of particulate organic carbon export in Franklin Bay (Canadian Arctic Environmental control and food web implications), J. Geophys. Res. 113, C03S05.

http://dx.doi.org/10.1029/2007JC004262

Waste decontamination and reuse research and ongoing projects

The Centre's waste decontamination and reuse research seeks to develop environmental mineral processing technologies (extraction of metals from solid waste, sludge, and ashes, restoration of contaminated sites, etc.), enhance the value of biomass and waste (production of biopesticides, biofuels and biosurfactants from sewage sludge, composting of agroalimentary waste, etc.), and improve urban and industrial waste decontamination (electrotechnologies for wastewater treatment, manure treatment, etc.). New technologies conceived at the INRS are regularly patented and transferred to industry.

• Hydrometallurgy and environmental mineral processing

Guy Mercier continued his research activities on the development of processes of metal extraction from contaminated soils, fly ashes, and hazardous waste. The recommended approach seeks to reduce costs and improve environmental results by increasing the metal recovery percentage in the industrial production cycle.

In a contract with the National Research Council Biotechnology Research Institute, **Guy Mercier** and **Jean-François Blais** study the combination in a single process of metal extraction by chemical leaching and PAH (Polycyclic Aromatic Hydrocarbons) extraction using a new non-toxic and biodegradable surfactant. A previous project had already highlighted the promising potential of this new technology.

Mario Bergeron and his team continued the development of a new production process for silicon tetrachloride, $SiCl_4$. This chemical compound is the base material used by optical fibre industries. It is also used for producing semiconductors and solar panels. This research team also works on technologies for soil and sediment decontamination.

• Biomass and waste reuse

With the objective of reducing greenhouse gases and reusing waste, **Guy Mercier** and **Jean-François Blais** are exploring the energy production potential of various sludge and waste materials and trying to determine the optimal mixtures for use in biomass boilers. They are documenting available technologies for drying these materials and calculating the energy budget of different approaches in consultation with liquid and solid waste producers.

Guy Mercier and **Jean-François Blais** are collaborating with **Patrick Drogui** on many research projects in partnership with industry. In one of these projects, they are developing technological solutions for the treatment of two important wastes of the aluminum industry, red mud and waste containing PAH. These researchers are working on physical and chemical separation processes that destroy or extract the inorganic and organic contaminants in order to make these wastes acceptable in landfills. They are also exploring ways of reusing the fluorine and treated residues. Another goal is to develop a process to transform red mud into a soluble coagulant usable for wastewater treatment.

This same research team has also been contracted to develop a new treatment technology using biofiltration for agroalimentary wastewater. The objective is to evaluate the reuse potential of sludge from wastewater and organic solid residue treatment for producing high-quality composts.

Olivier Bonin

For more information

Rouen, E., J. F. Blais, and G. Mercier. 2008. Transformation of red mud from aluminum industry into a coagulant for wastewater treatment. *Hydrometallurgy* 92, no. 1-2: 16-25.

http://dx.doi.org/10.1016/j.hydromet.2008.02.004

Rajeshwar Dayal Tyagi continued his work on the decontamination of sewage sludge using a biological process and the development of new processes for producing value-added products from decontaminated or fresh sludge. In partnership with industry, this researcher has begun a project to develop a biopesticide containing a baculovirus of the codling moth (a major pest of apple orchards). The goal is to obtain a viral insecticide in powder form that is safer and less expensive to export than liquid pesticides.

The Greater Moncton Sewerage Commission has mandated this researcher to carry out an evaluation of greenhouse gases production during sewage sludge treatment and reuse in order to integrate this component into their management strategies.

Satinder Kaur Brar is a new researcher-professor at the INRS. Her research interests relate to wastewater treatment, soil decontamination, bioprocesses, and transformation of sewage sludge and agricultural waste into value-added products. She has undertaken work on wastewater toxic organic compounds and the possible reuse and decontamination of sewage sludge by enzyme production based on solid-state fermentation. She collaborates with other organizations to develop value added products, such as microencapsulations, microemulsions, granules, powders, etc.

For more information

Brar, S. K., M. Verma, R. D. Tyagi, J. R. Valéro, and R. Y. Surampalli. 2006. Particle size variations during production of wastewater sludge-based *Bacillus thuringiensis* biopesticides. *Pract. Period Hazard. Toxic. Radioact. Waste Manage.* 12, no. 1: 30-39.

http://dx.doi.org/10.1061/(ASCE)1090-025X(2008)12:1(30)

• Urban and industrial decontamination

The Centre Eau Terre Environnement decontamination research team has over the years developed chemical and electrochemical processes of stabilization and conditioning (STABIOX and ELEC-STAB) and decontamination (METIX and ELECDEC) of sewage sludge. One of the objectives of **Jean-François Blais**'s research activities is to improve these two groups of technologies and increase their applicability.

Jean-François Blais collaborates with **Guy Mercier**, **Patrick Drogui**, **Mario Bergeron**, and **Rajeshwar Dayal Tyagi** on this objective, with the specific goal of improving the performance of these sewage sludge treatment processes by coupling them with ultrasound technology, which greatly improves the decontamination process. In addition to removing toxic metals, this new technology destroys pathogens and odours, an important advantage for the subsequent use of the decontaminated sludge.

Working again toward the improvement of these processes, **Jean-François Blais** has undertaken an industrial partnership project in collaboration with **Guy Mercier**, **Patrick Drogui**, and **Rajeshwar Dayal Tyagi** in which various electrolytic treatments are studied to increase metal recovery and destruction of organic contaminants during the decontamination of industrial wastewater and solid residues. They are developing a decontamination process for chromated copper arsenate treated wood, for example.

Another technology conceived at the INRS is a treatment process for pig manure (LISOX) that concentrates phosphorus into a solid that is economically transportable. **Guy Mercier**, **Jean-François Blais**, and **Patrick Drogui** are working together on an improved version of this technology that could eventually be used in the bovine industry. They are also assessing greenhouse gas emission during the LISOX process in order to minimize this effect.

Patrick Drogui is a new researcher-professor at the INRS. His research interests relate to the development of new technologies (electrotechnologies, advanced oxidation processes, electromembrane and physicochemical processes) for the removal of refractory emerging pollutants of organic, inorganic, and microbial types. The goal is to improve existing municipal and industrial wastewater treatment systems and replace ineffective conventional technologies for removing various types of contaminants

(endocrine-disrupting chemicals, phenolic compounds, PAHs, dioxins, organochlorinated compounds, insecticides, hormones and derivatives, drug metabolites, etc.).

Finally, **Patrick Drogui**, in collaboration with **Jean-François Blais**, worked on the problem of removing cyanobacteria and cyanotoxins from drinking water by testing the effectiveness of activated carbon treatment units. They evaluated the performance of the elimination process for these toxic micropollutants.

For more information

Drogui, P., M. Asselin, S. K. Brar, H. Benmoussa, and J. F. Blais. 2007. Electrochemical removal of pollutants from agro-industry wastewaters. *Sep. Purif. Technol.* 61, no. 3: 301–10.

http://dx.doi.org/10.1016/j.seppur.2007.10.013

Aquatic and terrestrial biogeochemistry research and ongoing projects

Research in biogeochemistry focuses on contaminant dispersion and assimilation and the effects of trace metals on aquatic organisms in order to detect environmental changes in lake ecosystems. Environmental geochemistry (source identification, transport and elimination of contaminants from aquatic environments by sedimentation, etc.), limnology (bio-optics, carbon fluxes, limnogeology, etc.), and ecotoxicology are the main research areas.

• Environmental geochemistry

The main objective of **Charles Gobeil**'s research is to acquire fundamental geochemical knowledge useful for interpreting sedimentary records of oceans and lakes. He studies the modification of element cycles caused by human activities, biogeochemical recycling at the water–sediment interface, the chronology of metal contaminant deposition in sediments, the origins of environmental contamination, and the role of Arctic Ocean sediments in the global element cycles of the world's oceans.

Charles Gobeil and honorary professor **André Tessier** collect and analyze sediments and interstitial water from isolated lakes in Quebec. Once modelled, the results of this work reveal the chronology of fluxes of atmospheric pollutants. To decipher the sedimentary records without ambiguity, they study chemical, physical, and biological processes concurrent with sediment deposition. This research enables them to evaluate the success of pollutant emission reduction measures and to predict possible impacts of new measures.

For more information

Chappaz, A., C. Gobeil, and A. Tessier. 2008. Geochemical and anthropogenic enrichments of Mo in sediments from perennially and seasonally anoxic lakes in Eastern Canada. *Geochim. Cosmochim. Acta* 72, no. 1: 170–184.

http://dx.doi.org/10.1016/j.gca.2007.10.014

Pierre Lafrance continued his research on the influence of biophysico-chemical processes on the evolution and transport of organic compounds in soil and groundwater at the local (agricultural field) and regional (watershed) scales. This research aims to further our understanding of contamination from diffuse sources and to apply the knowledge obtained to predict the transport of organic compounds within hydrosystems and treat soil contamination.

In collaboration with Quebec's Ministry of Natural Resources and Wildlife, **Claude Fortin** and **Alain Rousseau** seek to evaluate the consequences of forest harvesting on the chemical composition of alkaline lakes in the Chics-Chocs Wildlife Reserve (Gaspésie region) by following the physico-chemistry of six lakes, three of which have had part of their watershed harvested.

• Limnology

Isabelle Laurion collaborates with an environmental association devoted to protecting Lake Saint-Charles (APEL) on a limnological study in the upstream part of the Saint-Charles River watershed to try to determine the causes of the cyanobacterial blooms observed in the lake. Isabelle Laurion and her team evaluate the performance of *in vivo* fluorometers for monitoring cyanobacteria in lakes and examine interference factors. They are also interested in the factors that influence the recruitment of benthic forms of cyanobacteria dormant in the sediments.

In addition, **Isabelle Laurion** is interested in the effect of thermokarst ponds created by permafrost melting on carbon fluxes and greenhouse gas emissions in northern environments. She participates with **Pierre Francus** in a team project within the ArcticNet Network to acquire the necessary knowledge and tools to monitor the evolution of the thermokarst ecosystems already affected by climate change.

• Ecotoxicology

Peter Campbell continued to develop a model to predict the bioavailability of trace metals in aquatic organisms in natural environments. This model takes into account metal speciation, environmental factors, and the contribution of particulate metals to the bioaccumulation.

Peter Campbell is conducting several research projects in collaboration with **Claude Fortin**. In one of them, they work on developing molecular probes for evaluating quantitatively the bioavailability of trace metals dissolved in water in natural environments. The goal is to study the *in situ* response of aquatic organisms to help validate laboratory models.

Claude Fortin continued his research on characterizing the exposure of aquatic organisms to metals and the toxicological effects of metals in relation to bioavailability. As part of a team project, he also studied the capacity of cultivated algae to modify metal speciation in a controlled environment. The team's objective is to develop a new approach to evaluate the toxicity of metals in algae.

Isabelle Laurion

For more information

François, L., C. Fortin, and P. G. C. Campbell. 2007. pH modulates transport rates of manganese and cadmium in the green alga *Chlamydomonas reinhardtii* through non-competitive interactions: implications for an algal BLM. *Aquat. Toxicol.* 84, no. 2: 123-32.

http://dx.doi.org/10.1016/j.aquatox.2007.02.019

Patrice Couture's research program examines the mechanisms of metal toxicity in wild fish. Noxious effects have already been shown in yellow perch in lakes contaminated by mining operations and smelters.

On this subject, **Patrice Couture** and **Peter Campbell** are working in collaboration with industry to develop functional genomic tools to measure the response of yellow perch to stresses caused by metal contamination.

For more information

Brumit, V., P. Couture, P. G. C. Campbell, and L. Rematchet. 2008. Evolutionary ecotoxicology of wild yellow perch (*Perca flavescens*) populations chronically exposed to a polymetallic gradient. *Aquat. Toxicol.* 86, no. 1: 75-90.

http://dx.doi.org/doi:10.1016/j.aquatox.2007.10.003

One of the main objectives of **Landis Hare**'s research activities is to develop biological and geochemical models to predict the contamination level of lakes from that of several species of aquatic invertebrates.

For more information

Hare, L., A. Tessier, D. M. N. Cossa, . 2008. A barometer for tracking changes in the availability of lake water cadmium over space and time. *Hum. Ecol. Risk Assess.* 14, no. 2: 223-42.

http://dx.doi.org/10.1080/10807030801934838

Within the aquatic ecosystem group of the MITHE (Metals in the Human Environment) Strategic Network, **Landis Hare** leads and **Peter Campbell**, **Patrice Couture**, and **Claude Fortin** participate in a project on the transfer of trace metals within aquatic food chains. The processes driving the transfer of metals toward higher trophic levels are studied with field and laboratory experiments.

Dominic Poston

Geosciences research and ongoing projects

Geosciences research is highly diversified at the INRS. A unique example of a partnership between a university and a governmental organization, the Quebec Geosciences Centre groups scientists from the Centre Eau Terre Environnement and the Quebec division of the Geological Survey of Canada (GSC-Quebec). The joint objective is to develop efficient analytical methods for sedimentary environments and associated natural resources (fossil fuels and minerals). Environmental geosciences activities relate to the study of current geological processes and their environmental impacts and to the reconstruction of past environments using biological indicators. Climate change impacts are at the heart of the research in environmental geology. Hydrogeology also occupies an important place. For example, in collaboration with the Department of National Defence, INRS researchers have been studying groundwater contamination on Canadian military bases for several years. Geophysical applications in archaeology are also of interest.

• Geological environments and natural resources

Richmond Minerals Inc. is involved in mineral exploration in the south-western part of the Grenville geological province. It has contracted **Lyal Harris** to test for the presence of an iron oxide–copper–gold hydrothermal system in the Bondy gneiss complex (Mont-Laurier region).

Lyal Harris also continues his research activities on geological structures in extensional tectonic regimes and sedimentary basins with irregular margins by using numerical and physical modeling techniques and field studies.

For more information

Konstantinovskaya, E., J. Harris, J. Poulin, and G. Ivanov, 2007, Transfer zones and fault reactivation in inverted rift basins: Insights from physical modeling: *Tectonophysics* 441, no. 1-4: 1-26.

http://dx.doi.org/10.1016/j.tecto.2007.06.002

Michel Malo continued his research on the tectonics of orogenic fronts in the Appalachian Mountains. His goal is to analyze the crust deformation mechanisms in orogenic fronts to understand their influence on the development of the porosity and permeability of rocks that could contain fossil fuel reservoirs or ore deposits.

Within the DIVEX Network (Diversification of Mineral Exploration in Quebec), Michel Malo documents the geological and metallogenetic parameters of the Roberto gold deposit on Goldcorp's Éléonore property (James Bay region).

In collaboration with the Geological Survey of Canada, Michel Malo continues his research on the tectono-stratigraphic and structural context of the Appalachian Mountains in the Bas-Saint-Laurent region. Field data, compilation of recent work, and study of public seismic profiles will be used to support data on bedrock maturation and evaluation. The goal is to complete the coverage between Quebec City and the eastern limit of the Gaspésie region and to define areas of interest for fossil fuels.

For more information

D'Hulst, A., G. Beaudoin, M. Malo, M. Constantin, and P. Pilote, 2008, Geochemistry of Sainte-Marguerite volcanic rocks: implications for the evolution of Silurian-Devonian volcanism in the Gaspé Peninsula: *Can. J. Earth Sci./Rev. Can. Sci. Terre* 45, no. 1: 15-29.

http://dx.doi.org/10.1139/E07-012

Marc Richer-LaFlèche has several research activities financed by JAG Mines Ltd. Detailed lithogeochemical studies of limestone rocks and bituminous shales, as well as geophysical surveys, were carried out as part of a geochemical and geophysical analysis of the Ordovician sedimentary formations of the Lake Saint-Jean basin. This researcher also continued to work on a detailed geochemical study of fossil fuels, trace metals, and natural radioactivity in forest soils of the Témiscouata region. The data obtained in these two study regions will be used to check the fossil fuel potential of the basins. In a new project, Marc Richer-LaFlèche also examined Ordovician rocks of the Baie-Saint-Paul and La Malbaie area in the Charlevoix region. A geochemical study enabled evaluation of the lithological characteristics and oil and gas potential of this area.

Pierre-Simon Ross is a new researcher-professor at the INRS. His research interests relate to ore deposits associated with volcanic or magmatic activity such as volcanogenic massive sulphide deposits, porphyries, and kimberlites and their geological environments. In a multidisciplinary study on the Blake River group in the Abitibi region, he is studying mafic to intermediary volcanoclastic units in order to better understand the volcanic architecture and facilitate exploration for volcanogenic massive sulphide deposits. Many of these ore deposits are found in the Blake River group and hence mineral exploration is very active.

• Environmental geology

In collaboration with the Roche Consulting Group, **Bernard Long** participated in a seismostratigraphic analysis based on very high-frequency seismic reflection data for an expansion project of the port of Cotonou, Benin. This study sought to determine precisely the superposition of the different sedimentary facies (channels, abandoned arms, progradation zones) in the current entry pass of the lagoon and several ancient ones. In Quebec, this researcher has been working to determine the position of the bedrock roof and various older stratigraphic sequences in order to map the present compact sediments and those currently being altered in an area where new harbour structures are projected.

Within the GEOIDE Network, Bernard Long leads the FUDOTFRAM project (An Integrated Geomatics Project in Coastal Zone: Terrestrial, Airborne and Marine Data Fusion) in collaboration with the University of New-Brunswick at Fredericton and York University. The expected project result is the development of a reliable tool to assess and quantify coastal erosion and map the sedimentology and biology of the pre-coastal zone.

In the CAT-scan laboratory, this researcher and his team study sedimentary transport under steady flow and by gravitational movement.

Honorary professor **Michel Leclerc** has been mandated by Quebec's Ministry of Public Security to develop an analytical model for remediation solutions to coastal erosion. This model, built on a thirty-year horizon, incorporates a variety of economic approaches, including cost-benefit analysis in present values and multicriteria analysis. It takes into account different hypotheses relative to erosion, vulnerability, and climate change.

This researcher has carried out this type of analysis for the municipality of Pointe-aux-Outardes (Manicouagan region) in close collaboration with the firm Aquapraxis (for coastal engineering and numerical modeling of tides and waves) and the Ouranos Consortium (for climate change). The objective was to obtain a comparative assessment of different scenarios of erosion risk reduction in this municipality. Although solutions respecting the morphosedimentary balance of the coastal environment were preferred, retreat options were not excluded. The recommended approach included consulting and involving the local population and participative management. More than 100 municipalities of the Côte-Nord and Gaspésie regions of Quebec are at risk of coastal erosion.

Pierre-Simon Ross

• Paleoenvironmental studies

Paleoenvironments can be studied using annually laminated sediments (varves). This is the area of expertise of **Pierre Francus**, whose research program focuses on the integrated study of current sedimentary and limnological processes in lakes of the Canadian High Arctic. Analysis of long-varved sedimentary sequences makes it possible to reconstruct quantitatively past environments.

For more information

Besonen, M. R., W. Patridge, R. S. Bradley, P. Francus, J. S. Stoner, and M. Abbott. 2008. A record of climate over the last millennium based on varved lake sediments from the Canadian High Arctic. *The Holocene* 18, no. 1: 169-80.

http://dx.doi.org/10.1177/0959683607085607

Yves Bégin continued his work to reconstruct the hydrographic and hydrological changes that have occurred in subarctic Quebec in recent centuries. This dendrochronology-based project was initiated several years ago in collaboration with Hydro-Québec and the Ouranos Consortium and is now being integrated into phase II of the research activities of the ArcticNet Network. Yves Bégin leads the project and collaborates with researchers from the Geological Survey of Canada and the *Université du Québec*. The objective is to reconstruct the long-term natural variability of hydroclimatic parameters involved in modeling water supply in hydrographic basins important for hydroelectric production. Data are obtained from a dense network of dendrochronological stations, and woody subfossil material is utilized to extend the data further back in time. This work is carried out within the *Centre d'études nordiques*, an inter-institutional strategic research group.

For more information

Kröpelin, S., D. Verschuren, A. W. Lézine, H. Eggermont, C. Cocquyt, P. Francus, J. P. Cazet, M. Fagot, B. Rumes, J. M. Russell, F. Darius, D. Conley, M. Schuster, H. Von Suchodoletz, and D. Engstrom. 2008. Climate-driven ecosystem succession in the Sahara: the last 6000 years. *Science* 320, no. 5877: 765-68.

http://dx.doi.org/10.1126/science.1154913

An international project

Country: **Tchad**

Official languages: **French** and **Arabic**

Partners: Geologists of the University of Cologne (Germany); paleolimnologists from Ghent University (Belgium), and a consortium of experts from Germany, France, Sweden, Canada, and the USA

Funding: *Deutsche Forschungsgemeinschaft* (DFG) and Fund for Scientific Research of Flanders

As part of an international consortium of experts, **Pierre Francus** contributed to a multidisciplinary analysis of paleoenvironmental indicators in sediment cores extracted from Lake Yoa in northern Chad. This lake is one of very few in the Sahara that have been protected against desiccation by continuous groundwater inflow. The sediments of Lake Yoa are finely laminated. An analysis by micro X-ray fluorescence, conducted at the INRS in the laboratories of Pierre Francus, enabled determination of how the sediments were deposited and discrimination of each of the 6000 annual laminations (varves) using the ITRAX scanner of the GIRAS laboratory. The international study concluded that the drying of the Sahara was in fact a gradual process that occurred between 5600 and 2700 years ago, in response to a gradual decrease in tropical monsoon rainfall. This new environmental reconstruction of the Sahara environment strongly contrasts with the generally accepted hypothesis that the "green Sahara" which existed between 10 000 and ~6000 years ago had ended abruptly.

في مجتمع للخبراء الدوليين توصل السيد بيار فرانكيس إلى تحليـــل متعدد الإختصاصات للمؤشرات الموجودة بيئة البحيرات من خلال عينات أخذت من رواسب إستخرجت من بحيرة (يوا) بشمال التشاد .
إن بحيرة (يوا) توجد بها رواسب رقيقة الصفحات ، وهي واحدة من البحيرات النادرة التي تمت حمايتها من الجفاف بواسطة مجرى متواصل للمياه الجوفية .
التحليل المجهري الذي أجري بمختبرات بيارفرانكيس بواسطة (الفلوريسونس أيكس) بالمعهد الوطني للأبحاث العلمية توصل إلى كيفية تواجد الترسبات وإحتواء كل ترسب على 6.000 صفيحة سنويا من خلال السكانار إيتراكس (ITRAX) لمخبر (GIRAS) .
إن نتائج الدراسة الدولية تبين أن جفاف الصحراء هو ظاهرة تكونت تدريجـــيا بين 5.600 و 2.700 عام قبل اليوم و ذلك نتيجة الانخفاض التدريجي في الأمطار الموسمية الاستوائية .
هذه التهيئة الجديدة للبيئة بالصحراء تتماشى مع النظرية المتعارف عليها بأن (الصحراء خضراء) وهي من نوع أعشاب السفانا الاستوائيـة التي وجدت بيـن 10.000 و 6.000 عام قبل اليوم قد وصلت إلى نهاية فجائية .

Translation: Rimeh Daghri

• Hydrogeology

Within the Ouranos Consortium, **Alain Rousseau** and his team are collaborating on a new study on the impact of climate change and anthropogenic activities on groundwater levels and aquifer recharge in Canada. This study uses historical data series on base flow and well hydrograms to estimate temporal trends. These estimates will be combined with existing hydrogeological, climatic, and hydrological models to simulate scenarios of aquifer recharge in different regions of the country and under various climatic conditions.

Claudio Paniconi worked on modeling the interactions between surface water and groundwater at the scale of the sub-basin for the Châteauguay River. This research is part of the second phase of a project of the Ouranos Consortium. The goal is to improve hydrological mechanistic models in order to make them sensitive to interactions with groundwater and to develop new technologies of calibration and data assimilation. In parallel, Claudio Paniconi continued his research on the use of numerical models based on Richards' equation in hydrological analyses.

Claudio Paniconi also collaborated with **Richard Martel** and **Rene Lefebvre** on vat and column tests analyzing the design, implementation, and operation of an underwater collection system using horizontal wells.

The organization responsible for waste management in the Chutes-de-la-Chaudière region has mandated **René Lefebvre** to characterize the hydrogeological context of an old landfill site now covered. The site leachate is managed by natural attenuation. This project will guide future environmental management of the site. In other related research activities, René Lefebvre is working to spatially characterize and represent the heterogeneity of complex aquifer systems. Innovative approaches to detailed hydrogeological characterization are being used, in particular direct push sounding and geophysical surveys. The objective of these efforts is to contribute to a better understanding of contaminant flow and transport in aquifers.

René Lefebvre

René Lefebvre carried out numerical modeling of gas flow within the waste rock pile of the Sullivan mine in British Columbia, owned by Teck Cominco. This modeling helped explain how oxygen-depleted air filled a sampling shed and caused four fatalities in May 2006. These results enable a better understanding of the interactions between atmospheric conditions and gas transport in waste dumps, thus providing guidance for a new set of safety measures for these sites.

This researcher also offers scientific and technical support relative to the TCE (trichloroethylene) contamination problems in the area of the Valcartier military base.

For more information

Ouellon, T., R. Lefebvre, D. Marcotte, A. Boutin, V. Blais, and M. Parent. 2008. Hydraulic conductivity heterogeneity of a local deltaic aquifer system from the integrated 3D distribution of hydrofacies from borehole logs, Valcartier, Canada. *J. Hydrol.* 351, no. 1-2: 71–86.

http://dx.doi.org/10.1016/j.jhydrol.2007.11.040

Pursuant to agreements with the Department of National Defence, **Richard Martel** analyzed the evolution of different metals and contaminants in groundwater, many of them specific to military installations. Sites in Ontario and Alberta, as well as the Valcartier military base, were studied in this project.

This researcher also works in industrial partnership to develop a technology of *in situ* restoration of aquifers contaminated by oils. The technology combines soil washing with bioslurping and chemical oxidation followed by biological degradation. The final goal is to meet regulatory standards.

For more information

Bordeleau, G., R. Martel, S. Ampleman, and S. Thiboutot. 2008. Environmental impacts of training activities at an air weapons range. *J. Environ. Qual.* 37, no. 2: 308-17.

http://dx.doi.org/10.2134/jeq2007.0197

An international project

Country: **Ghana**

Official language: **English**

Partners: Water Resources Commission of Ghana, Water Research Institute of Ghana and community stakeholders

Funding: Canadian International Development Agency (CIDA)

Within a consortium formed by SNC-Lavalin and the INRS, **René Lefebvre** collaborates on a project to describe the groundwater resources of the semi-arid regions of northern Ghana and contribute to the development of the capacities necessary to manage these resources. In those regions, groundwater represents the principal source of quality drinking water for a population which mainly depends on agriculture. The work done up to now has enabled the grouping of all available information in a database, specification of the hydrogeological contexts of northern Ghana, and evaluation of the probability of drilling productive wells in different regions. Some of the work has also focused on evaluating the recharge capacity of the aquifers. The water supply capacity was revealed to exceed considerably the present level of groundwater use.

Erwan Gloaguen is a new researcher-professor at the INRS. His research interests relate to the integration of geophysical methods using geostatistical approaches. In one of his projects in collaboration with **René Lefebvre**, he is interested in assessing hydrogeological properties for environmental or shallow geotechnical applications. The objective is to better represent the heterogeneity of aquifers and to develop approaches to geostatistical integration of hydrogeological and geophysical data to represent the 3D distribution of hydraulic conductivity in quaternary deposits.

In a project financed by the company Vale Inco, **Erwan Gloaguen** seeks to improve 3D geological models of ore contents. This researcher also has projects on the development of new methods of geostatistical simulation based on multivariable analysis of wavelet coefficients from similar models and on the downscaling and fusion of macro and micro-CT data for reconstructing bone structure in 2 dimensions and at various scales.

• Geophysical applications in archaeology

Marc Richer-LaFlèche continued his archaeometry work in several projects located within Quebec City. For example, he used methods of electromagnetic induction and high-resolution georadar to locate archaeological artefacts on the site of a 17th century Jesuit house in Sillery and in three other sites that have been occupied since the 16th century in Cap-Rouge. Another part of his research activities consisted of developing a method of laser ablation analysis applicable to archaeomaterials in order to study ceramics of all origins. As a result, a database of spectral data from common and fine ceramics found abundantly in the archaeological contexts of the last four centuries in the St. Lawrence valley was built. Using a spectrophotometer, it is possible to characterize ceramic production and in some cases identify the mineral phases present in the paste. This technique was used for various collections. This researcher also completed an archaeometric and geochemical study of the Îlot des Palais collections.

Scientific collaboration

Quebec Geosciences Centre (QGC)

www.cgq-qgc.ca

The Centre Eau Terre Environnement of the INRS and the Quebec division of the Geological Survey of Canada (GSC-Quebec) are partners in a scientific collaboration agreement. The intent is to facilitate collaboration among researchers in the fields of regional geology, georesources, and environmental geosciences. Researchers of the QGC focus their activities on important socio-economic issues, increasing knowledge related to groundwater, minerals and fossil fuels, natural hazards, and climate change.

Research chairs

• NSERC/Hydro-Québec Industrial Research Chair in Statistical Hydrology

www.ete.inrs.ca/activites/groupes/chaire_hydrol/

Chairholders (Phase III: 2004–2009): Taha B.M.J. Ouarda (75%) and Anne-Catherine Favre (25%)

Collaborators: André Saint-Hilaire and Bernard Bobée

The phase III research program covers four main topics. Two of these ("Developing tools to assist in the design of hydroelectric structures" and "Analysis and modeling of time series") are in line with the work of the previous phases, whereas the two new ones ("Environmental statistical hydrology" and "Statistical hydrology in northern environments") meet the industrial partner's priorities on topics that have been little explored yet.

• Canada Research Chair in Environmental Decontamination

Chairholder: Jean-François Blais

This research involves the development of innovative procedures for decontaminating certain types of environments and industrial and urban waste, specifically sludge generated by wastewater treatment, fly ash produced by waste incineration, mine tailings, and soils polluted by toxic metals. The research group also works on finding ways of using waste for industrial purposes (e.g., as fertilizers).

• Canada Research Chair in Metal Ecotoxicology

Chairholder: Peter Campbell

It has been shown that assessment methods that have proven successful for the study of organic micropollutants (PCBs, DDT, etc.) are ineffective in assessing the impact of metals released into the natural environment. New approaches have to be developed to deal with this issue. The short-term objectives of the chair's work include a better understanding of the impacts of metals on the aquatic environment and the development of ecotoxicological diagnostic tools. Over the longer term, these tools will enable the definition of metal release standards that better protect the environment.

• Canada Research Chair in Hydrological Variable Assessment

Chairholder: Taha B.M.J. Ouarda

The chair's focus is on the study of watercourse flow variations based on hydrological data and statistical models. Hydrological variations are assessed both at the local level (for a specific watercourse) and at the regional level. At the local level, one of the objectives is to improve the assessment of rare events, such as flooding and low flows, required for the design of hydraulic work, while the assessment of hydrological variables on a regional basis can be used to compensate for the insufficient number of measuring stations. This research work will help to meet the challenges associated with climate change impact on water resources.

• Canada Research Chair on Bioconversion of Wastewater and Sewage Sludge into High-Value-Added Products

Chairholder: Rajeshwar Dayal Tyagi

The aim is to develop new ecological, cost-effective processes for treating and converting wastewater and sewage sludge to produce enzymes, bio-insecticides, bioherbicides, biofungicides, bio-inoculants, and bioplastics. The implications of this research are doubly significant. On one hand, residual biomass can be converted into safe, high-value-added products, and on the other hand, these products can serve to reduce or minimize dependence on chemical substances in agriculture, forestry, and industry.

Research groups and networks

The Centre Eau Terre Environnement's research is integrated into many inter-institutional groups in Quebec. Monique Bernier is co-director of the Centre for Northern Studies *(Centre d'études nordiques* (CEN): **www.cen.ulaval.ca**), whose scientific objective is to improve our understanding of the dynamics of cold- and frost-dominated environments. Yves Bégin, Pierre Francus, Isabelle Laurion, and Taha B.M.J. Ouarda are also members of the CEN. Jean-François Blais, Peter Campbell, Patrice Couture, Claude Fortin, Charles Gobeil, and Rajeshwar Dayal Tyagi are all members of the Inter-institutional Ecotoxicology Research Centre of Quebec (*Centre interinstitutionnel de recherche en écotoxicologie* (CIRE): **www.ecotox.uquebec.ca**). Norman Bergeron and André Saint-Hilaire are both members of the Inter-institutional Research Centre on the Atlantic Salmon (*Centre de recherche interuniversitaire sur le saumon de l'Atlantique* (CIRSA): **www.bio.ulaval.ca/cirsa/**). Norman Bergeron, Landis Hare, and Isabelle Laurion are regular members of the Inter-institutional Research Group on Limnology and the Aquatic Environment (*Groupe de recherche interuniversitaire en limnologie et en environnement aquatique* (GRIL): **www.gril-limnologie.ca**). Bernard Long and Pierre Francus are also members of the Research Centre on Geochemistry and Geodynamics (*Centre de recherche en géochimie et en géodynamique* (GEOTOP): **www.geotop.ca**). Lastly, Yves Gratton is a member of the Inter-institutional Oceanography Research Group of Quebec (*Groupe interinstitutionnel de recherches océanographiques du Québec* (Québec-Océan): **www.quebec-ocean.ulaval.ca**).

• DIVEX - Diversification of Mineral Exploration in Quebec

www.divex.ca

Network co-director: Michel Malo

Other researchers involved: Lyal Harris and Pierre-Simon Ross

This network is composed of about thirty earth scientists who share the common objective of supporting mineral exploration diversification with the help of scientific research.

• MITHE - Metals in the Human Environment

www.mithe-sn.org

Aquatic theme co-leader: Peter Campbell

Other researchers involved: Patrice Couture, Claude Fortin, and Landis Hare

The MITHE Strategic Network is a collaboration of academia, government, and industry. The Network conducts research in support of science-based environmental and human health risk assessments for metals in water, soil, and food.

• Ouranos - Consortium on Regional Climatology and Adaptation to Climate Change

www.ouranos.ca

Researchers involved: Yves Bégin, Alain Mailhot, Taha B.M.J. Ouarda, Claudio Paniconi, and Alain Rousseau

Ouranos is a Canadian consortium that brings together 250 scientists and professionals from different disciplines. It focuses on two main themes: *Climate Sciences* and *Impacts & Adaptation*.

• ArcticNet Network of Excellence

www.arcticnet.ulaval.ca

Theme leader (Phase I: 2004–2008): Yves Gratton (Physical Oceanography)

Project leaders (Phase II: 2008–2011): Yves Bégin (Analysis of Past Hydro-Climatic Variations in Nunavik) and Yves Gratton (Long-Term Observatories in Canadian Arctic Waters).

Other researchers involved: Monique Bernier and Isabelle Laurion

The ArcticNet Network brings together scientists and managers in the natural, human health, and social sciences and their partners to study the impact of climate change in the coastal Canadian Arctic. Over 100 ArcticNet researchers from 27 Canadian universities and 5 federal departments collaborate with research teams from 11 countries.

• GEOIDE Network of Excellence

www.geoide.ulaval.ca

Project leaders (Phase III: 2005-2009):
Monique Bernier (FRAZIL) and Bernard Long (FUDOTERAM)

Other researchers involved: Normand Bergeron and Karem Chokmani

The GEOIDE Network brings together many of the country's leading experts of the geomatics community from 50 universities, 80 companies, and 36 government agencies and departments. GEOIDE's mission is to consolidate and strengthen the Canadian geomatics industry, while making optimum use of Canada's research and development resources.

International initiatives

• International Polar Year

The International Polar Year (IPY) is a major international scientific programme focused on the Arctic and the Antarctic that started in March 2007 and will last until March 2009 in order to cover two full annual cycles of both polar regions. Several INRS researchers participate actively in IPY projects.

• A Canadian Arctic SOLAS Network

www.quebec-ocean.ulaval.ca/C-SOLAS/

Arctic SOLAS is the Canadian contribution to the International SOLAS (Surface Ocean - Lower Atmosphere Study) Project. The primary objective of SOLAS is to achieve quantitative understanding of key interactions and feedbacks between the ocean and atmosphere and of how this coupled system affects climate. **Yves Gratton** participates in Arctic SOLAS, which aims to provide critical knowledge about the impact of global warming on sea-ice-air gas and aerosol exchanges in the Canadian Arctic.

• Climate change and permafrost impacts on High Artic watershed fluxes: Cape Bounty, Melville Island experimental watershed observatory

geog.queensu.ca/cbawo/

This Canadian IPY research project seeks to investigate High Arctic watersheds to determine aquatic and terrestrial responses to climate change in this sensitive region. **Pierre Francus** is participating by reconstructing long term hydroclimate and ecological change through the analysis of annually laminated sediments.

• Climate change impacts on Canadian Arctic Tundra ecosystems: interdisciplinary and multi-scale assessments (CICAT)

www.ipytundra.ca/

This Canadian IPY project will constitute the first complete evaluation of the state of tundra ecosystems throughout the Canadian Arctic. It comprises a study of the changes in the vegetation, soils, and aquatic environments along a transect from the forest tundra to the Arctic tundra. **Isabelle Laurion** contributes to this project by evaluating the role of permafrost thaw ponds on carbon fluxes.

• Circumpolar Flaw Lead System Study

www.ipy-cfl.ca

This international IPY project headed by the University of Manitoba will bring together over 200 scientists from 15 countries for a multi-year climate change study in the Canadian High Arctic. **Yves Gratton** leads the research team on physical oceanography, which seeks to understand the physical processes occurring in the water column and to determine what controls the ice–ocean and the atmosphere–ocean exchanges.

• The Carbon Cycle in the Canadian Arctic and Sub-Arctic Continental Margin

Charles Gobeil leads this Canadian IPY project in which sediment cores will be collected along the margins of Canada's three oceans and analyzed for trace elements, carbon isotopes, and molecular tracers of carbon's origin. The study area includes the sub-Arctic Pacific, Bering, Chukchi and Beaufort Seas, Baffin Bay and Davis Strait, and the Canadian Archipelago. The results of this work will help in understanding the interactions between climate change and elemental cycles in the Arctic Ocean.

• MERGE-Canada: Arctic Microbial Ecosystems

www.cen.ulaval.ca/merge/

This is the Canadian partnership in the international IPY MERGE (Microbiological and Ecological Responses to Global Environmental change in the polar regions) project, whose general objective is to understand the responses of polar ecosystems to climate change. Within MERGE-Canada, **Isabelle Laurion** and her team are interested in studying the microbial diversity of permafrost thaw ponds.

• Variability and Change in the Canadian Cryosphere

Environment Canada leads this Canadian contribution to the international "State and Fate of the Polar Cryosphere" project, which is designed to observe and understand the current state of the cryosphere, to determine how fast it is changing and why, and to develop future scenarios of the cryosphere for use in impacts studies and planning. In Nunavik, **Monique Bernier** uses RADARSAT and SSM/I images for monitoring the ground freeze–thaw seasonal cycle and that of river and lake ice. **Taha Ouarda** also contributes to this project by using Bayesian methods to analyze the trends in some of the variables that define the cryosphere.

• A new international collaboration initiative: PASADO

www.ete.inrs.ca/projets/pasado/PASADO-Canada/

The Potrok Aike Maar Lake Sediment Archives Drilling Project (PASADO) is an international initiative within the framework of ICDP (International Continental Drilling Project). PASADO Canada was officially started in 2008. **Pierre Francus** leads this Canadian contribution to the study of past climate and the evolution of a maar crater (explosive volcano) in Laguna Potrok Aike, Southern Patagonia, Argentina. Ten Canadian researchers from eight universities are involved, including another INRS researcher, Pierre-Simon Ross.

Sharing knowledge

Publications

• Journal of Water Science

www.rse.inrs.ca/index.php?page=accueil

This publication is an international electronic journal publishing original research papers in pure and applied water science, notably in the areas of hydrology (surface and groundwater), water quality, hydrobiology, ecotoxicology, potable water and wastewater treatment, and water resources management. It is co-edited by the *Groupement d'Intérêt Scientifique des Sciences de l'Eau* (France) and the Centre Eau Terre Environnement. The journal celebrated its 20th anniversary in 2008.

Co-director: Peter Campbell

Editorial board members: Jean-François Blais and Alain Mailhot

Scientific board member: Bernard Bobée

• Scientific publications and communications

The complete listing of the 2007–2008 scientific publications and communications of Centre Eau Terre Environnement researchers is available online:

www.ete.inrs.ca/doc/publications2007-2008.pdf

Meetings and seminars

• 76th ACFAS Congress

www.acfas.ca/congres/2008/pages/faits_saillants.html

In 2008, the INRS hosted of the 76th ACFAS Congress from May 5th to 9th in Quebec City. The conference theme was "Knowledge meets 400 years of history". The ACFAS and INRS celebrated the International Year of Planet Earth with a series of four public meetings on current environmental issues, followed by a panel discussion including all of the guest speakers. Other activities linked to the 400th anniversary of Quebec City were organized for the general public, for example a tour of geological and historical sites of the city and a meeting titled "400 years of science in Quebec City".

Congress president: Jean-Pierre Villeneuve

Scientific committee members: Monique Bernier (president), Patrice Couture and Claude Fortin (life and health sciences), Michel Malo and Anne-Catherine Favre (physics, mathematics, and engineering)

Organizing committee chair: Sophie Duchesne

Environmental public meeting series: Aïcha Achab and Michel Malo

• Earth and Environmental Sciences Day

www.inrs-ete.uquebec.ca/conf/jste2008

On 28 March 2008, the Centre Eau Terre Environnement hosted the 9th edition of this joint *Université Laval* and INRS event, organized alternately by graduate students in earth and environmental sciences from these two academic institutions. This conference day is an excellent opportunity for graduate students to present their research results to an informed audience.

• Centre Eau Terre Environnement seminar program

www.ete.inrs.ca/index.php?page=1_6archives

The Centre holds scientific seminars throughout the year related to its different research fields. The complete listing of the seminars held in 2007 and 2008 is available online.

Public outreach activities

INRS researchers regularly give interviews and contribute to articles in the media (newspapers, radio, television, Internet) within their specialty field.

For example, the scientific program *Découverte* at Radio-Canada television broadcast a report on 30 March 2008 focusing on the Canadian RADARSAT 2 satellite, which enables better ice observations. The program highlighted the work of Monique Bernier and her team on the use of satellite data to characterize the nature and thickness of river ice, a very useful tool for preventing ice jams and floods. The report is available online on the Radio-Canada website.

In March 2008, the documentation and information service of the INRS launched a new series of information bulletins called *Capsules INRSciences*, which are designed to highlight in easily understood language and format the quality and diversity of research carried out by INRS students. The bulletins are available online on the INRS website.

The Centre Eau Terre Environnement student environmental committee was among the exhibitors at the 4th Symposium of Earth and Environmental Sciences held in Place Laurier (Quebec City) on 29 April 2008 as part of Earth Day activities.

Research excellence

Centre Eau Terre Environnement researchers and students received several awards and scholarships this year for the excellence of their research.

Professors **Satinder Kaur Brar**, **Jean-François Blais**, and **Rajeshwar Dayal Tyagi** received the 2008 Rudolph Hering Medal Award of the American Society of Civil Engineers (ASCE) for an article titled "Aerobic Biofiltration Processes - Advances in Wastewater Treatment" published in 2006 in the journal *Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management* (Volume 10, Issue 4, pp. 264-276).

At the International Water Association Specialist Conference held in Moncton in June 2007, **Rajeshwar Dayal Tyagi** received the Specialist Medal for Residuals Research awarded by the Specialist Group on Sludge Management to a researcher whose previous work has advanced both fundamental understanding and practical application in sludge, biosolids, and/or residuals management.

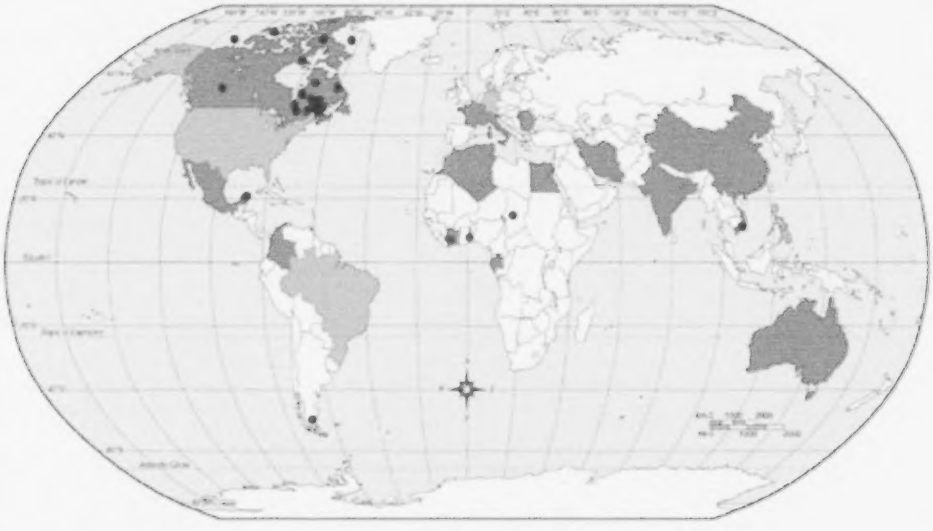
Koukou Adjalle, a PhD student in water sciences, received in 2008 one of the two Wladimir A. Smirnoff scholarships. The objective of this award is to promote research in the field of biological control of forest insect pests. Koukou Adjalle's research project is focused on developing an alternative formulation for BT (*Bacillus thuringiensis*) from agri-food industry wastewater and sewage sludge. He is supervised by professor Rajeshwar Dayal Tyagi.

The steering committee of the Trilateral Agreement Canada/Netherlands/Sweden on Defence Science and Technology Cooperation awarded a NATO Achievement Award to professor **Richard Martel.**

Finally, professor **Taha B.M.J. Ouarda** was among 22 Quebec personalities profiled in the special issue for the 400th anniversary of Quebec City of the magazine *Actualité* published in December 2007. Professor Ouarda was cited for his contribution to statistical hydrology research, a field in which he is a world expert.

A glance at the Centre's links throughout the world

In 2007-2008: Active research projects (blue dots); Countries of origin of researchers and students (in forest green); Countries of origin of co-authors of publications (in olive green).



The Centre's
vision is based
on a strong
environmental
commitment
and a rigorous
and innovative
scientific
approach

Training of highly qualified personnel

The students of the Centre Eau Terre Environnement of the INRS are in direct contact with real and concrete problems in water and earth sciences. Six graduate programs are offered. The inter-university Master's and PhD programs in earth sciences result from a collaboration with the Geology and Geological Engineering Department of the *Université Laval*. The students are registered in either institution but are trained by both. This collaboration has several advantages for the students: a wider choice of research subjects, a more extensive list of courses and an access to the services offered by both institutions. Students also benefit from the partnership between the INRS and the Geological Survey of Canada, which substantially increases the number of potential research advisors.

The Centre's graduate programs:
www.ete.inrs.ca/index.php?page=4_1

Water sciences programs

• PhD in water sciences

Several scientific disciplines are required to understand problems in water resources and aquatic environments, and a real and complete multidisciplinary approach is necessary to find solutions. This program is designed to train specialized researchers able to define and solve these problems and hence to meet society's needs in this domain. Students in this program will widen and deepen their general knowledge in water sciences while specializing in one of the specific fields of studies.

• Master's in water sciences

The INRS is the only institution in Quebec to offer a Master's in water sciences. This program enables students to acquire the specialized knowledge necessary to study the problems associated with this fundamental resource. In the thesis program, students can demonstrate their originality and aptitude for research while specializing in one or two fields of interest, selecting from a choice of three courses.

• Professional Master's in water sciences

The Master's program without thesis is designed to train professionals in executing and managing water science projects. Through the general knowledge and specialization obtained, graduates are able to make a significant contribution to solution finding and decision making in this area. This program also seeks to meet the continuing education needs of water science professionals.

Joan Daniel Bourgault

Personality

Claudie Beaulieu comes from Dolbeau in the Lac Saint-Jean region. She did several undergraduate internships with Professor Taha Ouarda's team before joining the INRS Master's program in water sciences in 2003, where she continued working with Professor Ouarda's team. Her colleagues quickly noticed that she was an excellent researcher and an inviting, always smiling worker. She collaborated on no less than 21 publications and presentations, about 15 as first author. She subsequently received a PhD scholarship from the FQRNT. Specializing in Bayesian statistical methods, she has worked on a diverse range of projects, including corrective methods for biased climatic data sets to improve the quality of precipitation and global change prediction models, climatic conditions favourable to the propagation of the West Nile virus in Québec, and modeling of ships' squat (the additional sinkage caused by their movement) in the St. Lawrence shipping channel. Claudie will soon complete her PhD and undertake a postdoctoral fellowship at the prestigious Princeton University in New Jersey. Her present colleagues will not miss her for too long, however, since she will be returning often as a collaborator.

Jean-Daniel Bourgault

Earth sciences programs

• PhD in earth sciences

This program offers advanced specialization in various fields of fundamental and applied geology and geological engineering. The program is designed to train students to conceive and set up original research projects, to lead projects on their own, and to excel in professional research or university teaching activities.

• Master's in earth sciences

In the Master's thesis program, students acquire advanced general knowledge, deepen their knowledge in a specific field, are introduced to scientific research, and are trained in the professional practice of geology, hydrogeology, or geological engineering.

• Master's in earth sciences - Environmental technologies

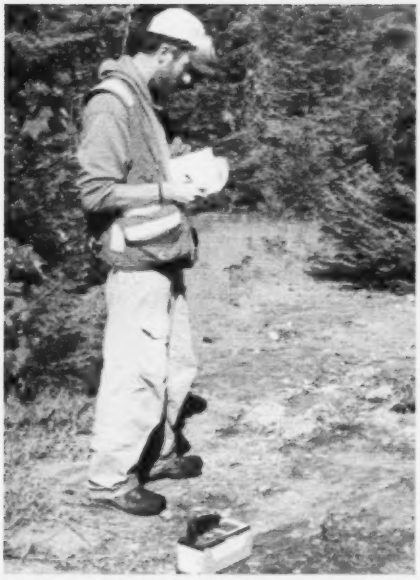
This program with essay leads to a Professional Master's degree specializing in environmental technologies. In most jobs, employees are confronted with environmental problems. Practical approaches for problem solving are interdisciplinary and require diversified knowledge from a whole set of disciplines.

The Professional Master's is focused on environmental technologies used in civil, chemical, geological, and agroalimentary engineering and in the environmental sciences of soil, water, and air decontamination, waste recycling, and pollution reduction.

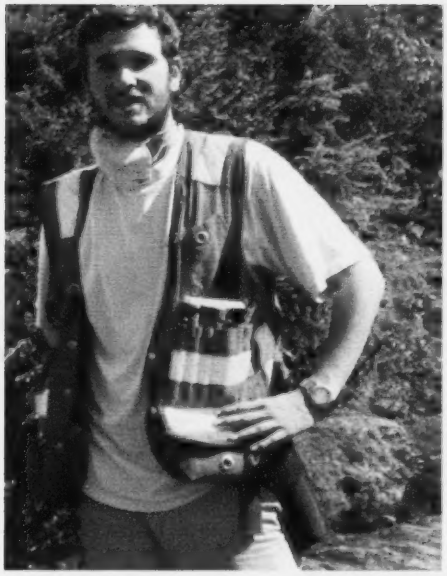
Marc Fichet-Lefèbvre

Personality

Quebec turned out to be a good destination for two French students looking for a scientific adventure. **Vladimir Antonoff** (left photo) and **Gregory Dufrechou** (right photo), from the Bretagne et Beam regions of France respectively, came to the INRS to work together on two aspects of the same project: the processing and interpretation of regional geophysical data, as well as structural controls of mineralization (Gregory), the petrology and geochemistry of mineralization and alteration zones (Vladimir) in the south of Mont Laurier (Grenville geological province). The analyses carried out by these two dynamic PhD students (supervised by professors Lyal Harris and Marc Richer-LaFleche of the INRS and Louise Corriveau of the GSC-Quebec) have already resulted in a ground geophysics program and exploratory drilling to search for copper (and potentially for gold and silver) by Richmond Minerals Inc., the partner company, conducted during the summer and winter of 2008.



Gregory Dufrechou



Vladimir Antonoff

Internships and fellowships

As part of its mission to conduct research and train highly qualified personnel, the INRS welcomes postdoctoral fellows within its research teams. Postdoctoral scholarships are available.

INRS postdoctoral fellowships:
www.inrs.ca/Francais/index.jsp?page=StagesPostDoc

Each summer, the Centre Eau Terre Environnement offers undergraduate internships, an excellent opportunity for students to gain a research experience in the fields of water, environmental sciences, and natural resources in a highly stimuling scientific environment.

The Centre's summer internships:
www.ete.inrs.ca/index.php?page=1_5

High-quality research infrastructure

The Centre Eau Terre Environnement of the INRS is located in downtown Quebec City on the urban campus of the *Université du Québec*. Its research teams have access to state-of-the-art laboratories (ITRAX scanner, scanning electron microscope, ultra-clean laboratory, plasma-atomic emission spectrophotometer, etc.).

Ressources naturelles Canada

Jean-Daniel Bourgault

In addition, a new $60-million laboratory building has just been opened. It is located in the Metropolitan Quebec Technology Park and will be used to conduct research in partnership with the private sector and other partners. This new building contains high-tech equipment unique in Canada, including CAT scan and environmental biotechnologies laboratories. These facilities will enable the scaling of technologies developed at the INRS.

Isabelle Martineau

Finally, a research station located at Sacré-Cœur (Saguenay region) offers to INRS research teams a work and educational facility for seminars, training courses, study projects, and scientific meetings in a natural environment. The station is also available for inter-university collaborations.

Yves Régyn

Shared services laboratory

The shared services laboratory located in the downtown building comprises a general laboratory and several specialized laboratories in microbiology, radioisotopes, chemical analyses, sample preparation, microscopy, trace metals, etc. The operating mode of this laboratory is unique in that all equipment and instruments bought by professors using their grants are pooled and are available to everybody. This enables optimal use of all resources. A complete range of high tech instruments is thus at the disposal of everyone involved in experimental research at the INRS.

Research laboratories

State-of-the-art laboratories are available to INRS researchers in both the downtown building and the new laboratory building in the Metropolitan Quebec Technology Park.

The new multidisciplinary CAT-scan laboratory of the INRS is a unique facility in Canada. It comprises a CAT-scan room, a data storage and treatment unit, a sedimentology laboratory, and hydraulic, biosedimentology, and hydrology equipment. Work in hydrogeology is supported with high-tech equipment such as a geotechnical drilling rig, sounding equipment, and a new data acquisition system using electrical tomography, which enables environmental characterization of aquifers. The INRS biogeochemical research team has also obtained a new, state-of-the-art inductively coupled plasma-atomic emission spectrophotometer to be used in the Laboratory of Trace Metal Measurements in Aquatic Samples. A second spectrophotometer (Varian Cary 300), also bought this year, is dedicated to enzymatic tests. The LAPAHR and GIRAS laboratories of the INRS are both structured around the same high-tech piece of equipment, the ITRAX™ Core scanner, which enables the analysis of lake and marine sediments.

The partnership between the Centre Eau Terre Environnement of the INRS and the Quebec division of the Geological Survey of Canada (GSC-Quebec) allows the pooling of high-quality geosciences laboratories accessible to the entire research community. For example, the GSC digital cartography and photogrammetry laboratory offers to users expertise and high-quality services in acquisition, management, analysis, and dissemination of geoscientific data.

For more information on the Centre Eau Terre Environnement research laboratories:

www.inrs-ete.uquebec.ca/index.php?page=laboratoires

- High-Resolution Paleoclimatic Analysis (LAPAHR)
- Environmental Technologies (Decontamination)
- Bioconversion of Wastewater and Sewage Sludge into High-Value-Added Products
- Bio-Optics and Microbial Ecology
- Ultra-Trace Geochemistry
- Geochemistry, Imagery, and Radiography of Sediments (GIRAS)
- *In situ* Decontamination of Soil and Groundwater (Joint lab INRS–DRDC–Valcartier)
- Trace Metal Measurements in Aquatic Samples
- Multidisciplinary CAT Scan
- Physical, Digital, and Geophysical Simulation
- Direct Push and Rotary Percussion Sounding System
- Remote Sensing and Geomatics

For more information on GSC Quebec research laboratories:

cgc.rncan.gc.ca/org/quebec/lab_e.php

- Analytical Geochemistry (Joint lab INRS–GSC–Quebec)
- Stable Isotope Geochemistry (Delta-Lab)
- Hydrogeology
- Dendrochronology and Dendrogeochemistry
- Digital Cartography and Photogrammetry Laboratory (LCNP)

Centre Eau Terre Environnement
community

- professor
- research technician
- research associate
- research officer
- research assistant
- postdoctoral fellow
- PhD
- Master's
- intern
- others

❍ of one of the above colors:
left or graduated during the year

Research and teaching

Research teams

- Jean-Christian Auclair

- Mario Bergeron
  - Marie Létourneau
  - Alain Langlais
  - Gérald Dermont
  - Jorge Enrique Medina-Lopez
  - François Larouche
  - Maxime Bergeron

- Normand Bergeron
  - Francis Bérubé
  - Marc-André Pouliot
  - Patricia Johnston
  - Mylène Levasseur
  - Jean-Nicolas Bujold
  - Joanie Côté
  - Jérôme Dubé
  - Francis Gauthier
  - Véronique Tremblay
  - Gisèle Wagner
  - Élisabeth Simard
  - Véronique Tremblay

- Monique Bernier
  - Mohamed Niang
  - Yves Gauthier
  - Lisa-Marie Pâquet
  - Md. Shah Alamgir
  - Maria Dissanska
  - Rébecca Filion
  - Imen Gherboudj
  - Kim Huong Hoang
  - Stéphane Mermoz
  - Hugo Drouin
  - Karine Labrecque
  - Audrey Lessard-Fontaine
  - Charles Gignac
  - Aurélien Gonzalez
  - Pierre Étienne Lord

- Jean-François Blais
  - Myriam Chartier
  - Isabel Beauchesne
  - Samuel De la Rochebrochard
  - Amélie Janin
  - Dikenane Kombila
  - Stéphanie Lafond
  - Lan Huong Tran
  - Mélanie Asselin
  - Mélanie Pinatton
  - Véronique Turcotte
  - Sandra Bernard
  - Médard Bouda
  - Vanessa Catherine
  - Otmane Gaboune
  - Jihen Ben Khaled
  - Marian Moucheroud
  - Louis César Pasquier
  - Jean-Philippe Pavard
  - Halima Saghir
  - Marie-Christine Simard
  - Med Aly Souissi

- Satinder Kaur Brar

- Bernard Bobée (emeritus)
  - Ouejdane Samoud

- Peter Campbell
  - Isabelle Papineau
  - Fabien Pierron
  - Sophie Cooper
  - Kristin Mueller
  - Frédéric Maloney
  - Yvan Tremblay
  - Josianne Caire
  - Anne Crémazy

- Karem Chokmani
  - Ahmed Houcine
  - Benjamen Raphaël-Amanrich

- Patrice Couture
  - Charles Gauthier
  - Dominique Lapointe
  - Vincent Bourret
  - Nicolas Garceau
  - Sophie Gentès
  - Berangère Leclercq
  - Angela Sacchi

- Daniel Cluis (honorary)
  - Julie Corriveau
  - Mathieu Quenum
- Patrick Drogui
  - François Zaviska
  - Erika Miatti
  - Isidore Moukame
- Sophie Duchesne
  - Thai Nam Pham
- Anne-Catherine Favre
  - Karine Dion
  - Nguyen Bao Trinh
  - Guillaume Evin
  - Thomas-Charles Fortier-Filion
  - Jonathan Jalbert
- Claude Fortin
  - Jonathan Bernier
  - Laura François
  - Michel Lavoie
  - Nathalie Paquet
  - Gabrielle Roy
  - Jessica Pickford
- Pierre Francus
  - Jean-François Cremer
  - David Fortin
  - Frédéric Bouchard
  - Nicoleta Ciobanas
  - Stéphanie Cuven
- Erwan Gloaguen
- Charles Gobeil
  - Sandra Jobidon
  - Antony Chappaz
  - Raoul-Marie Couture
  - Danielle Dubien
  - Stéphane Feyte
  - Marie-Noëlle Bernatchez
  - Marie-Ève Randlett
- Yves Gratton
  - Véronique Lago
  - Marie-Emmanuelle Rail
  - Annie Simard
  - Claude Bélanger
  - Dany Dumont
  - Romain Lanos
  - Somayeh Nahavandian Esfahani
  - Caroline Sévigny
  - Loïc Degroote
- Landis Hare
  - Louis Croisetière
  - Isabelle Proulx
  - Maïtée Dubois
  - Julie Dumas
  - Dominic Ponton
  - Victor Thomasson
- Lyal Harris
  - Elena Konstantinovskaya
  - Vladimir Antonoff
  - Gregory Dufrechou
  - François Leclerc
  - Jimmy Poulin
  - Philippe Bertrand
- Marc Richer-LaFlèche
  - Yves Monette
  - François Pelletier
  - Maxime Aubert
  - Jean-Christophe Aznar
  - Bruno Boussicault
  - Yves Caron
  - Geneviève Meunier
  - Édith Chouinard (office agent)
- Pierre Lafrance
  - Cédile Doukouré
- Isabelle Larocque
  - Nicolas Rolland
  - Vicky Tremblay
- Isabelle Laurion
  - Julie Breton
  - Catherine Vallières
  - Leira Retamal
  - Sophie Caplanne
  - Christiane Dupont
  - Annabelle Waren
  - Sébastien Bourget
  - Alexandra Rouillard
  - Gabriel Sarasin
  - Shobei Watanabe
- Michel Leclerc (honorary)
  - Paul Boudreau
  - Pierre-Luc Fortin
- René Lefebvre
  - Jean-Marc Ballard
  - Thomas Ouellon
  - Belkacem Lahmira
  - Daniel Paradis
  - Laurie Tremblay
  - Marc-André Carrier
  - Gregory Routin
  - Anna Baranski
  - Isabelle Maltais

- Bernard Long
  - Louis-Frédéric Daigle
  - Antoine Collin
  - Antoine Cottin
  - Stéphane Montreuil
  - Régis Xhardé
  - Karine Nault
  - Valérie Robitaille
  - Yann Keramoal
  - Patrick Labonté

- Alain Mailhot
  - Ahmadi Kingumbi
  - David Huard
  - Richard Turcotte
  - Samuel Bolduc
  - Guillaume Talbot

- Michel Malo
  - Karine Bédard
  - Valérie Bécu
  - Gaëlle Grundman
  - Adeline Parent
  - Jean-François Ravenelle
  - Stéphanie Roy
  - Kenneth Williamson
  - Esther Bordet
  - Émilie Tremblay-Paquet

- Richard Martel
  - Clarisse Deschênes-Rancourt
  - Uta Gabriel
  - Étienne Girard
  - Coffi Léonard Agassounon
  - Geneviève Bordeleau
  - Alain Gravel
  - Mathieu Lavoie
  - Nicolas Roy
  - Angus Calderhead
  - Mathieu Laporte-Saumure
  - Jeffrey Keith Lewis
  - Aurélie Bellavance-Godin
  - Geneviève Bordeleau
  - Guillaume Comeau
  - Marie-Claude Lapointe
  - Valérie Nadeau
  - Geneviève Parent
  - Marie-Catherine Poulin-Talbot
  - Vincent Boulianne
  - Marie-Christine Cantin
  - Sandra Fournier
  - Alexandre Gauvin
  - Roxanne Saint-Laurent
  - Véronika Varfalvy

- Guy Mercier
  - Nathalie Meunier
  - Aurélie Dhenain
  - Romain Barbaroux
  - Ghislain Bongo
  - Emmanuelle Cecchi
  - Anaïs Charles
  - André Drouin
  - Julia Mouton
  - Élaine Boutin
  - Ilham Aissaoui Fqayeh
  - Charles-Edouard Nanci
  - Nathalie Siméon
  - Nam Tran
  - Véronique Turcotte
  - Marie-Claude Boivin
  - Catherine Cloutier
  - Haffad El Hassan
  - Thomas Lamberet
  - Charles-Edouard Nancy
  - Kathy Plamondon
  - Margot Thouvenin

- Taha B.M.J. Ouarda
  - Salaheddine El Adlouni
  - Naveed Khaliq
  - Ousmane Seidou
  - Huiling Cao
  - Christian Charron
  - Nicolas Gignac
  - Étienne Boucher
  - Fateh Chebana
  - Eghbal Ehsanzadeh
  - Maryam Kamali Nezhad
  - Hadiza Moussa Saley Zouzou
  - Chang Shu
  - Lampouguin Bayentin
  - Claudie Beaulieu
  - Loubna Benyahya
  - Edgar Herrera-Guzman
  - Bahaa Khalil
  - Mathieu Ribatet
  - Mohamed Ridha Tekaya
  - Yves Tramblay (co-supervision)
  - Mohamed Aymen Ben Aissia
  - Chantal Caouette
  - Christian Charron
  - Barbara Martel
  - Imen Zaier
  - Iris Klein
  - Isabel Moreau
  - Rym Ouachani

- Claudio Paniconi
  - Cintia Racine
  - Mauro Sulis
  - Marie-Josée Gauthier
  - Catherine Guay
  - Frank Ferber
  - Marie Lefrancq
  - Lorenzo Sassi
- Pierre-Simon Ross
- Alain Rousseau
  - Stéphane Savary
  - Martin-Pierre Lavigne
  - Alexandru Ioan Ciobanas
  - Sylvain Jutras
  - Brou Konan
  - Sylvain Weill
  - Patrick Gagnon
  - Martine Grenier
  - Grégor Levrel
  - Rémi Bourdillon
  - Clément Clerc
  - Brigitte Laberge
  - Guillaume Rogel
  - Simon Ricard
  - Sylvain Kouajou Akpo
  - Philippe Boucher
  - Damien Kintz
  - Aimé Koudou
  - François Lasbleis
  - Philippe Noël
  - Ludovic Paul
  - Marc-André Robin
  - Martin Seto
  - Alain Royer (computer technician)
  - Sébastien Tremblay (computer technician)
- André Saint-Hilaire
  - Anik Daigle
  - Jacquie Diatezua
  - Valérie Ouellet
  - Simon Tardif
  - Mohammed Aziz Es Salhi
  - Nicolas Guillemette
  - France Godin
- Yves Secretan
  - Maude Giasson
  - Pascale Matte
  - Moua Yi
- Normand Tassé
- André Tessier (honorary)
  - Patrice Tremblay
- Rajeshwar Dayal Tyagi
  - Son Yan
  - Kokou Adjalle
  - Muriel Auriol
  - Jyothi Bezawada
  - Jean-Philippe Chenel
  - Zied Djedidi
  - Mathieu Drouin
  - Jean-Robert Gnepe
  - Thanh Tung Lai
  - Josée-Anne Majeau
  - Ha Pham Thi Thanh
  - Bala Subramanian Sellamuthu
  - Mausam Verma
  - Dang Khanh Vu
  - Son Yan
  - Gaelle Aupiais
  - Noëllie Bourdoiseau
  - Fanny Bourges
  - Antoine Coyac
  - Guillaume Poulin
  - François Vatin
- Jean-Pierre Villeneuve
  - Phu Duc Nguyen
  - Trang Hong Nguyen
  - Annie Poulin
  - Richard Turcotte
  - Maude Ouellet
  - Caroline Albert (office agent)
  - Alain Garon (computer technician)
  - Béatrice Morel (office agent)
  - Diane Tremblay (secretary)

Other professors

Emeritus

Georges Drapeau
Michel Slivitzky

Honorary

Aïcha Achab
Jean-Pierre Fortin
Guy Morin
Jean-Louis Sasseville
Alain Soucy

Associate

Guy Ampleman, DRDC-Valcartier
Jean H. Bédard, GSC-Quebec
Christian Bégin, GSC-Quebec
Andrée Bolduc, GSC-Quebec
Sébastien Castonguay, GSC Quebec
Louise Corriveau, GSC-Quebec
Benoît Dubé, GSC-Quebec
Mathieu J. Duchesne, GSC-Quebec
Donna Kirkwood, GSC-Quebec

Denis Lavoie, GSC-Quebec
Patrick Mercier-Langevin, GSC-Quebec
Yves Michaud, GSC-Quebec
Jean Morin, Environment Canada
Léopold Nadeau, GSC-Quebec
Miroslav B. Nastev, GSC-Quebec
Michel A. Parent, GSC-Quebec
Luc Perreault, Hydro-Québec
Didier Perret, GSC-Quebec
Nicolas Pinet, GSC-Quebec
Christine Rivard, GSC-Quebec
Alfonso Rivera, GSC-Quebec
Martine Savard, GSC-Quebec
Sonia Thiboutot, DRDC-Valcartier

Lecturers

Louis Fontaine, BPR

Claude Jean, Tremblay Bois Mignault Lemay

Yvon Maranda, *Ministère du Développement durable, de l'Environnement et des Parcs*

Luc Valiquette, *Ministère du Développement économique, de l'Innovation et de l'Exportation*

Other students

Supervised by GSC-Quebec associate professors

Anne-Laure Bonnet (PhD, Louise Corriveau)
Annick Doucet (PhD, Martine Savard)
Lise Lamarche (PhD, Michel A. Parent)
Mathieu Gingras (Master's, Christian Bégin)
Catherine Guay (Master's, Miroslav B. Nastev)

In the professional Master's program

Mohamed Ayad
Guillaume Barbier
Vincent Boucher
Anaïs Courteille
Julie Deault
Nicolas Francoeur-Leblond
Gianny François
Véronique Gagnon
Marie-Hélène Gendron
Guillaume Germain
Renée Gravel
Martin Tremblay

Independent

Lise Audet
Lisanne Chauvette
Catherine Fortier
Karine Hubert
Marie-Ève Vadnais
Julie Veillette

Invited researchers and professors

From foreign countries

Trois Arbeiter, *British Antarctic Survey* (United Kingdom)

Aristeo M. Gil, *Centro Interamericano de Recursos del Agua* (CIRA, Mexico)

Olivier Banton, *Université d'Avignon* (France)

Andreas Bardossy, *Universität Stuttgart* (Germany)

Françoise Bichon, *Institut français du pétrole* (France)

Riadh Ben Cheikh, *École nationale d'ingénieurs de Tunis* (Tunisia)

Alin A. Carsteanu, *Instituto Politécnico Nacional* (Mexico)

Bernard Chocat, *Institut national des sciences appliquées de Lyon* (INSA, France)

Daniel Cossa, *Institut français de recherche pour l'exploitation de la mer* (IFREMER, France)

Jean-Pierre Deslan, CNRS (France)

Carlos Díaz Delgado, CIRA (Mexico)

Janine M. Galvão Soliz, CIRA (Mexico)

Jean-Louis Goergen, *Institut national polytechnique de Lorraine* (France)

Stuart Lane, *University of Leeds* (United Kingdom)

Michel Lang, CEMAGREF (France)

Corinne Leyval, *UMR 7566 – CNRS & Université de Nancy I* (France)

Jean-Louis Morel, *Institut national polytechnique de Lorraine* (France)

Emmanuel Naffrechoux, *Université de Savoie* (France)

Eric Potter, *Institut d'électronique et de télécommunications de Rennes* (France)

Louis Prieur, *Laboratoire d'océanographie de Villefranche* (France)

Éric Sauquet, CEMAGREF (France)

Marie-Odile Simonnot, *Institut national polytechnique de Lorraine* (France)

Jaume M. Verges, *Institut de Ciencies de la Terra Jaume Almera* (Spain)

Alan L. Watchman, *Australian National University* (Australia)

Tran Minh Y, *Vietnamese Academy of Science and Technology*, (Vietnam)

Fakhi Zidane, *Université Hassan II* (Maroc)

Du Canada

Marc Amyot, *Université de Montréal*

Philippe Archambault, *Institut Maurice Lamontagne*

Simon Bernard, *EcoNews Experts-conseils*

Hamel Benmoussa, *Centre de recherche industrielle du Québec*

Louis Bernatchez, *Université Laval*

Gilles Boulet, *Ministère du Développement durable, de l'Environnement et des Parcs* (MDDEP)

Services

Direction

Yves Bégin (director)
Jean-Philippe Boivin (intern)
Roxane Dubé (secretary)
Jacques Gauthier-Duchesne (intern)
Isabelle St-Jacques (director secretary)
Martine Villeneuve (intern)

Administration

Jean-François Belley (intern)
Dominique Cantin Jean-Léon Doyon
Nicole Laflamme (administration head)
Diane Lortie
Marie-Noëlle Ouellet
Mylène Paradis
Alain Poirier
Manon Poitras
Louise Robitaille

Building

Céline Bélanger
Vincent Boulanger-Martel (intern)
Gilles Guérin
Éric Lortie
Serge Marcoux (service head)

Documentation and information

Jean Daniel Bourgault (service head)
Pascale Dion
Sophie Magos (left during the year)
Isabelle Martineau
Chantal Paquin
Zeljka Ristic-Rudolf (left during the year)
Anne Robitaille

Laboratories

Anissa Bensadoune
Sébastien Duval
Pauline Fournier
Michele Geoffroy-Bordeleau
Philippe Girard
Réal Gosselin
Marc Greendale
Jérôme Grenier-Desbiens (intern)
Richard Lévesque (intern)
William Philibert (intern)
Stéfane Prémont (service head)
Lise Rancourt
René Rodrigue
Sey-Hana Saing (intern)

Computer service

Claude Blanchette (service head)
Claude Champagne
Mireille Duval (intern)
Martin Gagné
Louis-Michel Gauthier (intern)
Luc Jalbert
Patrick Laforte
Marc Saint-Pierre

Valorization of research

Carole Parent

Cartography

Marco Boutin

Some **statistics** about the Centre

In the Centre there are in 2007–2008:

39 researcher-professors
11 emeritus and honorary professors
23 associate professors
64 invited researchers and professors

80 Master's students: 29 in earth sciences and 51 in water sciences
109 PhD students: 31 in earth sciences and 78 in water sciences
12 students in the Professional Master's program
16 postdoctoral fellows
86 undergraduate and graduate interns

109 articles published in scientific journals
47 published scientific communications
233 oral and poster presentations
13 books and book chapters
41 research reports (public et private)
16 PhD theses
20 Master's theses
10 internership reports of the Professional Master's program

6 graduate studies programs
5 research chairs

And many research units (laboratories, groups, networks, etc.)

Financial report

Revenues and expenses of operating fund (x $1000)

For the financial year ending May 31, 2008

Revenues		
Total institutional revenues		9 188
Other revenues		2 642
Research grants		
• NSERC	2 046	
• FQRNT	517	
• Other sources	2 393	
Total grants		4 956
Research contracts		7 890
Total revenues		24 676
Expenses		
Research and teaching		18 213
Support for research and teaching		
• General administration fees	1 554	
• Investments (furnishings and equipment)	114	
• Documentation and editing	417	
• Administration of Centre	286	
• Computer service	228	
• Laboratories	607	
• Land and buildings	1 999	
• Heavy-duty laboratories	190	
• GSC agreement	157	
Total support for research and teaching		5 552
Total expenses		23 765
Excess of revenues over expenses		**911**
Transfer to capital fund		-463
Net excess of revenues over expenses		**448**

Financial report

Centre reserves (x $1000)

For the financial year ending May 31, 2008

Operating fund reserve	
Accumulated surplus on 31 May 2005	1 711
Operating surplus on 31 May 2006	540
Operating surplus on 31 May 2007	970
Operating surplus on 31 May 2008	448
Total surplus	3 669

Capital fund reserve	
Unused balance on 31 May 2005	745
Balance transferred 2005-2006	550
Balance transferred 2006-2007	900
Adjustment 2005-2006	1 442
Unused total balance on 31 May 2006	3 637
Use of funds to finish reimbursing Édifice Québec	**-2 853**
Unused balance forecasted on 31 May 2007	784
Unused balance on 31 May 2008	131

Reserve for research space - Édifice Québec	
Unused balance	567
Balance transferred 2005-2006	741
Unused balance on 31 May 2006	1 308
Balance transferred 2006-2007	370
Use of funds to finish reimbursing Édifice Québec	**-1 678**
Balance transfer forecasted in 2007-2008	550
Actual balance transferred in 2007-2008	245
Use of funds to finish reimbursing Édifice Québec	-245
Total	0

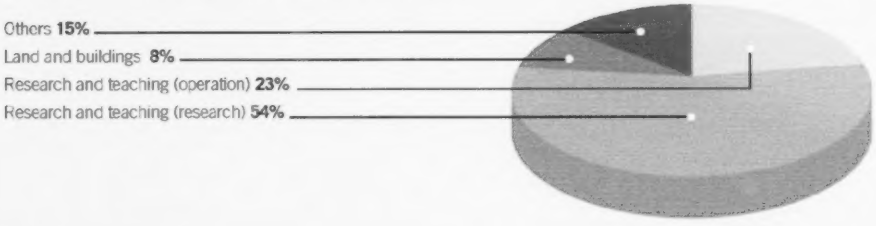
Financial report

University expenses by function (x $1000)

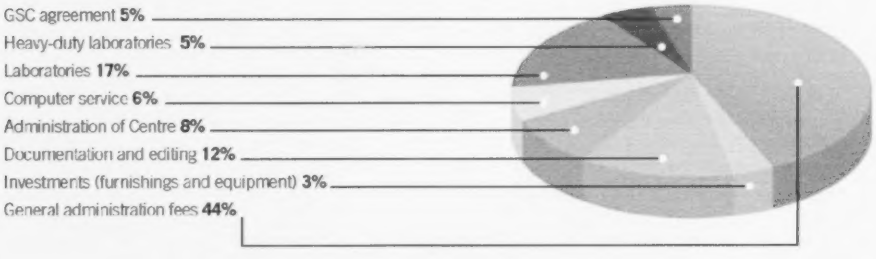
For the financial year ending May 31, 2008

	Salaries, benefits and scholarships	Field work, travel, supplies and material	Professional, contractual and public services; rent	Total
Research and teaching (operation)	4 345	93	929	**5 367**
Research and teaching (research)	2 807	705	9 334	**12 846**
General administration fees	715	55	784	**1 554**
Investments (furnishings and equipment)	0	0	114	**114**
Documentation and editing	321	1	95	**417**
Administration of Centre	241	27	18	**286**
Computer service	369	2	-143	**228**
Laboratories	468	1	138	**607**
Land and buildings	386	5	1 608	**1 999**
Heavy-duty laboratories	0	1	189	**190**
GSC agreement	79	15	63	**157**
Total	9 731	905	13 129	23 765

Research, teaching, land and buildings, and others: $23 765 000



Other functions: $3 553 000



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